THE
GLASS
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HIGH TEMPERATURE SYMPOSIUM

by Leon E. Sobon, STANFORD RESEARCH INSTITUTE, MENLO PARK, CALIFORNIA

Early in October, 1959, about 750 scientists, engineers, and industrialists from seven countries met to review the progress in fundamental research and commercial applications of new high temperature materials and processing techniques. The conference, the Second International Symposium on High Temperature Technology, was arranged by Stanford Research Institute and was held at Asilomar, a live-in conference facility on California's Monterey Peninsula.

The Proceedings of the first symposium, "High Temperature — A Tool for the Future," held in June, 1956, have since become an important reference for workers in high temperature research. Since the first symposium, developments have accelerated in fields dependent on high temperature research. The purpose of the second symposium was to present these developments, the products of many disciplines (e.g., ceramics, chemistry, physics, aerodynamics, etc.), to an audience of various disciplines, to permit interchange of ideas and integration of new knowledge. Preprints of all papers were provided.

IMAGE FURNACE RESEARCH

by C. P. Butler

NAVAL RADIOLOGICAL DEFENSE LABORATORY

● THIS IS PRIMARILY A DESCRIPTION of the carbon arc-image furnace, a relatively new tool being used in the field of high temperature research.

Whether the radiating source is the sun, the crater of a carbon arc, or the filament of a tungsten lamp, an image furnace does no more than collect as much as possible of the emitted energy and concentrate it into a single plane.

The energy source of the common arc-image furnace is similar to—and in many cases is—a high intensity motion picture projector arc used with combinations of mirrors to refocus the image. Successful operation of the unit depends largely on the properties of the material to be heated. For example, considerable energy input is required to melt sapphire, which transmits most of the radiant energy supplied to it, whereas a material like zirconium oxide can be melted easily.

Applications are varied. Medical research is using the arc-image furnace to study flash burn and cutaneous burn production in rats, pigs, and humans, and the mechanisms responsible for burns caused by exposure to nuclear detonations.

Ignition of solid propellants also has been studied. The amount of energy supplied to the specimen is easily controlled, and ignition can be measured relative to ambient pressure and other controllable factors. Similar principles have been used in investigating radiation ignition of fine fuels and the rapid pyrolysis of alpha-cellulose.

Among the speakers were, back row, left to right: J. White, England; H. Flood, Norway; Hisao Mii, Japan; W. Lochte-Holtgrevin, Germany; and M. Foex, France; (right foreground) L. Bratt and R. M. Burns, Stanford Research Institute.

Of more immediate interest to persons working in glass and ceramic research are measurements of thermophysical properties of ceramics and metals with the use of the arc-image furnace. Thermal diffusivity, specific heats, thermal expansion, reflectivity, and emissivity are some of the properties being measured. Specially designed test chambers with glass or quartz windows to admit the radiant energy are being used and boundary conditions can be closely controlled.

Single crystals of high-temperature refractory semiconductor materials are being grown using a modification of the Verneuil, or flame-fusion, technique with radiant energy as the heat source. A glass furnace chamber permits atmosphere control and facilitates maintaining maximum purity.

EXPERIMENTS WITH HIGH INTENSITY ELECTRIC DISCHARGES

by A. C. Ducati, G. M. Giannini and R. W. Waniek

GIANNINI PLASMADYNE CORPORATION

Arc heating and magneto-plasma methods of bringing a gas to high temperature were discussed; the former in greater detail.

The plasma jet uses the principle of arc heating, and it is basically a high-intensity constricted arc in which the working gas is heated to dissociation.

The jet is a valuable high-temperature tool. The production of hyperthermal hypersonic streams of gases is important in solving the critical problems associated with hypersonic flight. One unit is capable of operating continuously at temperatures up to 25,000°F.

Presently, the plasma jet is being used for ablation studies of glass fiber laminates and other materials, for spray coating of refractory metals and carbides, for aerodynamic studies of surfaces, and for study of such gas properties as relaxation times, recombination rates, and transport properties.

THE ACCURACY AND PRECISION OF MEASURING TEMPERATURES ABOVE 1000°K

by H. J. Kostkowski

NATIONAL BUREAU OF STANDARDS

The precision, accuracy, and limitations of temperature standards, instruments, and techniques were reviewed, and improvements which could be expected within the next few years were indicated. Emphasis was on temperatures below 20,000°K because of the greater quantitative information available, and because of their present technological interest. A bibliography of recent significant publications was included.

Improvements in the accuracy and precision of the International Temperature Scale can be expected within a few years when the standard thermocouple and optical pyrometer are replaced by a platinum resistance thermometer and a photoelectric pyrometer.

The most reliable thermocouple today is reported to be the platinum vs. platinum-10 per cent rhodium. The National Bureau of Standards certificates of calibration state that thermocouples of this type are accurate to within 0.25 per cent up to 1300°C, and it is possible to obtain reproducibility of 0.1°C for short periods of time up to 1100°C.

Of the more than fifteen thermocouples with melting points above 2000°C, tungsten vs. iridium and iridium vs. iridium-40 per cent rhodium are the only two which appear reliable. The former has been calibrated to 2100°C

with an accuracy better than ± 6° and the latter, to 2100°C with a maximum error of 10°. Both must be used in an inert atmosphere.

The platinum resistance thermometer has a greater precision than any other thermometer available today—fifty times more precise at 630°C, the antimony point, than a thermocouple. Experimental models have proven that a drift of less than 0.001 degree per hour at 1100°C is possible.

A commercial optical pyrometer which has been properly calibrated can measure temperatures to within 4° at 1063°C, the gold point, and to within 6° at 2000°C.

Of the new temperature measuring devices photoelectric optical pyrometers are the most promising. Preliminary studies have shown that measurements can be made to within 0.1° at 1063°C. A reliable instrument has not yet been perfected. However, serious efforts are under way, and it is expected that an instrument of this type will be used in the NBS calibration program within a year.

Two-color optical pyrometers were discussed. Although there are specific applications where a two-color pyrometer would be preferred, the instrument is not suited for general use where extreme accuracy is required.

Spectroscopic methods are being used at NBS to determine temperatures in the 1000° to 50,000°C range; best efforts to date in the 10,000° to 25,000°K range report a precision of 1 per cent and an accuracy within 5 per cent.

MEASUREMENT OF FLUX, EMITTANCE, AND RELATED PROPERTIES

by Henry H. Blau, Jr.

ARTHUR D. LITTLE, INC.

The general principles involved in developing reliable techniques for measuring emissivity at high temperatures. Two techniques now being used were described, as well as some typical experimental results. Thermal radiation properties, materials, temperature and heat flux measurements, and the interdependence of thermal properties at high temperatures were briefly covered.

Measurements of heat flux and emissivity in the solar and arc-image furnaces have been made and, by using these, the surface temperatures of the material being heated have been calculated. The pertinent instrumentation and methods of measurements were described, and the influence of surface conditions of the sample were pointed out. High-frequency induction furnaces are being used to study emissive properties in known controlled atmospheres.

THE INTERACTION OF HIGH TEMPERATURE AIR WITH MATERIALS DURING RE-ENTRY

by Mac C. Adams

AVCO-EVERETT RESEARCH LABORATORY, EVERETT, MASSACHUSETTS

and

E. Scala

MANAGER, AVCO RESEARCH AND DEVELOPMENT DIVISION WILMINGTON, MASSACHUSETTS

Many problems are encountered when designing a nose cone. This paper describes the various steps which were taken in the solution of the re-entry heat shield problem. The following areas were briefly covered:

1. Theory of ablation; material requirements; and various physical properties necessary for a good ablating material.
2. Laboratory experiments for selecting and evaluating materials. Apparently the best laboratory facility at present is the arc-heated air jet; best materials so far are high temperature ceramics (magnesia, silica, and beryllia).
3. Brittle fracture and thermal stress problems.
4. Materials development and fabrication techniques. Metal-honeycomb reinforced ceramics were found to be the most resistant to thermal shock.

A comparison was given between predicted and measured ablation results for a high-temperature ceramic nose cone which was recovered after a 5,000-mile flight test.

REFRACTORY METALS

by Robert I. Jaffee

BATTELLE MEMORIAL INSTITUTE

The refractory metals, tungsten, rhenium, osmium, tantalum, molybdenum, iridium, columbium, ruthenium, hafnium, rhodium, vanadium, and chromium were described. Their availability, extraction, consolidation, and fabrication were covered in detail. Tables and graphs—containing some previously unpublished data—of the mechanical, physical, and thermodynamic properties augmented the description.

The melting point, crystal structure, and other properties of a refractory metal were discussed in relation to its position in the periodic table.

The causes of low temperature brittleness in some of the metals were reviewed, and methods of improvement presented. Present work on alloying both for high-temperature strength and low-temperature ductility was discussed.

Oxidation behavior and methods of protection against oxidation were covered, as well as various applications of the refactory metals.

OXIDES FOR HIGH-TEMPERATURE APPLICATIONS

by W. D. Kingery

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The refractory oxide materials were reviewed, their properties tabulated and compared, and the effect of the many variables on the properties noted. Chemical stability at high temperature, and the effect of various atmospheres on alumina, beryllia, magnesia, zirconia, and thoria were discussed. Useful tables listed the reaction temperatures of the oxides with each other, and the degrees of reaction with various metals.

Oxide materials are generally stable in contact with refractory metals and carbides, but at sufficiently high temperatures, all react. Although thoria is the most resistant oxide in contact with many materials, magnesia is the most satisfactory crucible material to contain basic liquids such as PbO, $PbSiO_2$, and $CaSiO_2$. No material is really satisfactory for slags high in FeO. For normal silicate glasses and acid slags, zirconia and thoria are very resistant to attack; many other refrac-

tories, such as alumina, chromite, silica, and mullite are only slowly corroded.

The strengths of refractory materials can be expected to be increased by several orders of magnitude as processing control techniques improve. Impurities, grain size, and porosity are probably the most important variables affecting high temperature strength; to prepare good materials these must be controlled.

Thermal properties of main interest at elevated temperatures are melting point, thermal expansion coefficient, heat capacity, thermal emissivity, and thermal conductivity. Fracture strength and impact resistance are important, as well as thermal shock resistance; work on improving these qualities in oxides must be continued.

GRAPHITE, CARBIDE, NITRIDE, AND SULFIDE REFRACTORIES

by L. M. Litz

NATIONAL CARBON COMPANY

An extensive discussion was given on carbon and graphite, including raw materials and fabrication, and their effect on the properties of the material. A comprehensive review of the refractory carbides, nitrides, and sulfides was also given. The general background and methods of preparation were discussed, and tables and nomographs of the thermodynamic, mechanical, and physical properties were included.

The nuclear and mechanical properties of graphite have made it the ideal structural material for thermal reactors. Very high purities ($<$ 20 ppm total ash) are easily maintained. Graphite cloth, a new form of this material, is prepared from cloth fibers or felt processed to about 3000°C. It is 99.9-plus per cent carbon, is graphitic, has good electrical conductivity, and increases in strength with temperature to a maximum at about 2500°C. Individual graphite yarns have shown tensile strengths as high as 15,000 psi.

In the research on the coating of graphite, the two popular approaches to low permeability are high-pressure baking and impregnation by deposition of pyrolitic carbon; that is, carbon formed by the pyrolysis of a gaseous hydrocarbon. Although many coatings utilizing various refractory compounds in a variety of approaches are being developed, the most promising are those utilizing some types of silicon compound such as SiC, Si_3N_4, or mixtures of these.

Silicon carbide has a wide commercial usage; new developments will make the material even more useful. Recent work on self-bonded silicon carbide has yielded materials having four times the flexural strength and modulus of elasticity of the more conventional nitride or ceramic-bonded materials; at elevated temperatures the ratios are even greater. Recent approaches of imbedding granules of graphite in a matrix of SiC has produced a structure extremely resistant to thermal shock, oxidation, and erosion. Titanium carbide, which has been studied extensively, has remarkable mechanical and thermal properties, and good oxidation resistance. Uranium carbide is receiving considerable attention as a reactor fuel element.

Cermets are finding new uses as wear-resistant parts in bearings, valves, pumps, and gauges. A silicon carbide-molybdenum material has been found to have a transverse rupture strength which increases from 42,200 psi at room temperature to 71,900 psi at 1000°C—one of the highest values measured at this temperature.

Nitrides having the largest potential for use as refractories are boron, aluminum, and silicon. Commercially available is a boron nitride which has a modulus of rupture of 20,000 psi, is easily machinable, and has a decomposition temperature of 3000°C. It is being used as a mold wash for glass molds; it is not wetted by most molten metals and has excellent high-temperature thermal and electrical insulating properties. A cubic form of BN was recently produced which has a hardness in the range of diamond and is stable to high-temperature oxidation.

Of refractory sulfides, only cerium monosulfide has received much attention; it is being used as a crucible material for metals and reactive halides.

MATERIALS AND TECHNIQUES FOR THERMAL TRANSFER AND ACCOMMODATIONS

by Harry A. King

AEROJET-GENERAL CORPORATION

The surfaces of missile nose cones, rocket nozzles, combustion chambers, and re-entry vehicles are subjected to incredibly high heat fluxes, and the search continues for materials which will perform satisfactorily. This paper discusses advantages and disadvantages of the techniques being utilized, and notes those materials which are of interest.

Six basic techniques under study are:

1. *Conduction*: utilized by placing a material such as copper, which acts as a heat sink, between the heat source and the component being protected.

2. Convection methods divide into two classes: (*a*) *transpiration cooling* which utilizes a porous ceramic or metal wall through which a coolant is injected; and (*b*) *film cooling* which makes use of spaced orifices through which a coolant is passed.

3. *Radiation*: by using coatings of gold or platinum which are good reflectors at high temperatures, or dull black surfaces which are good radiators.

4. Combinations of the above techniques: *insulation*, and *ablation* (by removal or wearing away of a surface in a hyperthermal environment).

5. *Physical state changes*: methods of cooling by the absorption of heat that accompanies sublimation, melting, or vaporization. (Chemical state changes would include endothermic reactions.)

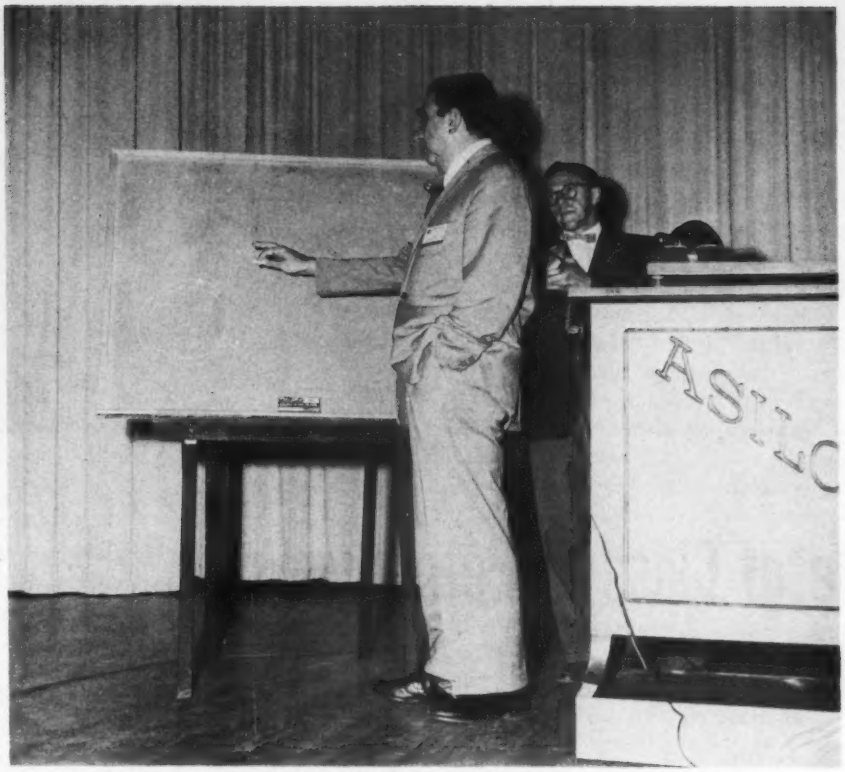
6. *Electrical and magnetic effects*: utilizing magnetohydrodynamics to create a field of force to resist heat transfer; and by translating the heat to another form of energy, e.g., the thermoelectric materials.

SILICIDES, BORIDES, ALUMINIDES, INTERMETALLICS, AND OTHER UNIQUE REFRACTORIES

by J. H. Westbrook

GENERAL ELECTRIC COMPANY

This fourth review paper on refractory materials covers the remaining materials which are of interest to high-temperature technology. Their structure, bonding, and preparation were discussed, and their constitution was illustrated by phase diagrams.



Nuclear physicist, Dr. Edward Teller, Director of the University of California Radiation Laboratory, delivering the keynote address in which he described experiments on the peaceful use of nuclear energy.

Borides and silicides have the attractive properties of their low density, high melting point, chemical stability, and high hardness. Both are brittle at room temperatures but may develop limited plasticity at elevated temperatures. The silicides are more oxidation-resistant than the borides because of the rapid formation of a stable protective coating of silica. Although only limited data are available on these compounds, there are many indications of very good high temperature properties.

Commercial bonded chromium borides are available which are employed mainly for their excellent corrosion and wear resistance at moderate temperatures.

Unfortunately, the germanides and stannides are a neglected area of materials research. The phosphides also have been studied but little, and seem to deserve more attention. Present applications are in the field of semiconductors (GaP and InP), and in wear-resistant nickel phosphide coatings.

By contrast, the intermetallic compounds have received considerable recent attention, and much has been published on their properties. Though brittle, relative to metals, intermetallics—have high room-temperature impact strengths compared with other compounds—because of their high-metallicity bonding. Present or potential applications of intermetallics exploit their unusual structural, magnetic, chemical, nuclear, or electronic properties. Although much effort has been spent on developing structural applications for these materials, their inadequate low temperature toughness has always proved a setback. Bonding with a ductile phase has been attempted thus far without success, but it still seems to be the main road to developing strucural adaptability.

HIGH PRESSURE METHODS

by H. Tracy Hall

BRIGHAM YOUNG UNIVERSITY

This discussion, by the developer of a commercial process for producing man-made diamonds, began with a description of pressure in terms of energy. In order to effect a chemical reaction, pressures in the order of 100,000 atmospheres, combined with rather high temperatures, are necessary. High-pressure systems have been designed capable of reaching 200,000 atmospheres with temperatures of 2500°C, sometimes as high as 10,000°C for one or two seconds.

All of the important high pressure methods were discussed, and some successful liquid and solid pressure transfer media were given. The principle of massive support where pressures greater than the ultimate compressive strength of the die materials are obtainable was described. The descriptions were aided by drawings of the various die configurations.

CONDENSED STATE REACTIONS AND PHASE EQUILIBRIA

by Allan W. Searcy

DEPARTMENT OF MINERAL TECHNOLOGY
UNIVERSITY OF CALIFORNIA, BERKELEY

Primarily concerned with solution phenomena in con-

(*Continued on page* 163)

Photographs by H. E. Miller, The Pure Oil Company

FIG. 1

The Role of Glass in Petrochemicals

by L. E. Hutchings and Joseph Walker, THE PURE OIL COMPANY

● PETROCHEMICALS are tailor-made materials; some are gases, others are almost glass-like and in some way owe their existence to petroleum. Most often they appear as plastics, but they also might be used as fertilizers, paints, polishes, rubbing alcohol, or a host of other products.

Petrochemicals, in addition to having been derived from the crude oil recovered from the ground, owe part of their existence, in many important respects, to glass. Without glass the research and development work necessary to create petrochemicals would have been almost impossible. A modern chemical research laboratory today is a maze of bottles, test tubes, flasks, glass distillation columns, beakers, burettes, graduates, separatory funnels and pipettes. A few of the more complex items in use are described in this article. Fashioned by skilled glass blowers, this glassware is essential to the development or production of many petrochemicals, which could not be made as simply or used as readily if they were made from any material other than glass.

FIG. 2

In the preparation of a successful petrochemical it is important to know the composition and purity of the raw materials. Crude petroleum consists mainly of carbon-hydrogen compounds. In addition it may contain smaller amounts of carbon-hydrogen-nitrogen, carbon-hydrogen-sulfur, or carbon-hydrogen-oxygen compounds. The greater portion of the sulfur-containing compounds are generally removed during refining, in order to eliminate corrosive tendencies and improve the odor of the refined product. Particular attention is given to sulfur control in the low-boiling fractions such as those used in making gasoline, naphthas or feed stocks to petrochemical processes.

The sulfur content of liquid petroleum products is determined by a direct burning procedure in a prescribed wick lamp within a closed system containing an artificial atmosphere composed of 70 per cent carbon dioxide and 30 per cent oxygen. A solution of hydrogen peroxide is used to absorb the oxides of sulfur formed during combustion and to oxidize them further to sulfuric acid. The absorbent containing the acid is then titrated with a standard alkali solution. The sulfur is calculated from the weight of the sample burned and the amount of alkali

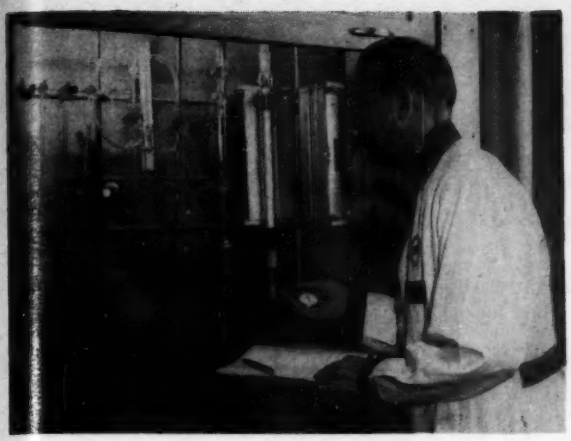


FIG. 3

used in neutralizing the acid which was absorbed.

Determining Sulfur Content

Chemically resistant glass parts used in this apparatus are illustrated in Fig. 1. The small wick lamp holding the fluid to be burned is located at the base. We also use a "glass-tee-burner" consisting of two concentric glass tubes, the external tube having a side arm which admits the gas. This section is provided with standard-taper glass joints for connecting the lamp flask with the glass chimney. The chimney has standard-taper glass joints also for connection with the burner and the absorber. The chimney and the flask are provided with glass hooks by which the three glass parts are held together with rubber bands.

The next piece is the glass absorber in which the oxides of sulfur are removed from the combustion gases. A glass fritted disk of 150-200 microns porosity is sealed in the larger of the two bulbs that form the absorber and assists in obtaining complete absorption. A glass spray trap prevents the liquid absorber from reaching the vacuum system. A vacuum must be applied to draw the combustion gases through the system.

The large, elongated glass bulbs shown at the back of the apparatus are auxilliary scrubbers, with their sealed-in, coarse, sintered disks. Vacuum regulators are also fabricated from glass and keep the flow of gas even. This equipment is arranged so that up to 10 determinations can be made at one time.

In addition to tests on raw materials, the properties of the intermediate materials in a petrochemical process must be accurately measured, so that uniform, dependable products can be made.

Determining Molecular Weight

Such an intermediate chemical derived from products of petroleum may be a polymer. Since the properties of that polymer depend on the number of molecules in its chemical chain, it is therefore necessary to determine the molecular weight of the large polymer molecule.

When a non-volatile substance, such as a large polymer, is dissolved in a pure solvent, the boiling point of the solution is higher than that of the pure solvent alone by an amount proportional to the number of non-volatile molecules dissolved in the solvent. Thus by noting the increase in the boiling temperature accompanying the solution of a known weight of substance in a suitable solvent, the molecular weight of the substance can be calculated. This is done with an ebulliometer (see cover), an apparatus consisting of two identical units.

In order to obtain reliable molecular weights, extremely precise measurements of temperature differences must be made—on the order of few thousandths of a degree Fahrenheit. Thus the central part of this apparatus, where the actual temperature measurement is made, is insulated by a vacuum jacket and by hot vapors surrounding the inner tube and contained in the outer tube.

Every precaution is taken to eliminate temperature fluctuations as a result of changes in room temperatures. The temperature differences are measured by means of thermistors (materials whose electrical resistances change appreciably with changes in temperature) inserted in the innermost glass parts where the solvent or solution containing the substance of unknown molecular weight is boiling. The electrical signals from the thermistors are fed to an electronic amplifier and read from a meter.

The low cost of most petrochemicals and products made therefrom depends to a large extent on the fact that these materials are made in huge quantities with a minimum of manpower and equipment. In order to make chemicals in these large quantities the counterpart of the assembly line in automobile manufacture must be used; that is, the continuous process. One of the essential ingredients to this process is a reactor in which the desired chemical manipulations can take place. In the reactor a catalyst is often used, consisting of specially composited and treated solid materials in the form of powder or pellets.

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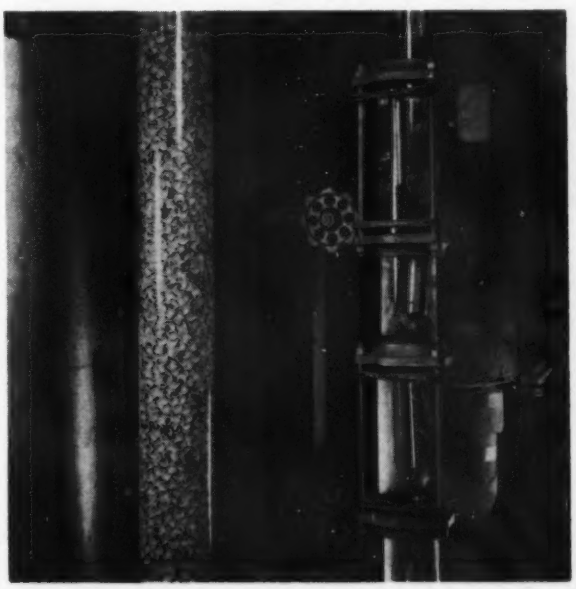
FIG. 4



STUDY OF GLASS AND MOLD TEMPERATURES in Commercial Glass Container Forming Operations

by H. H. Holscher, J. C. Coleman and C. C. Cooke, OWENS-ILLINOIS TECHNICAL CENTER, TOLEDO, O.

Methods and procedures have been developed for measuring both glass surface and mold surface temperatures obtaining in the manufacture of glass containers. Data are given for several typical types of glass containers manufactured in two colors of glass on the Owens machine and for flint wide-mouth items made by a press-and-blow process.

The methods of temperature measurement described are unique, and it is believed they will be found applicable for studies of such temperatures obtaining in varied processes of glass fabrication.

(Conclusion of a two part article.)

4. Mold Temperature Data

4.1. Mold Temperature Measurements on Owens Beer Bottle (Flint and Amber)

● IN THE DISCUSSION of mold temperature measurements, the Owens machine which was operating with a 12 oz. capacity, 12 oz. weight beer bottle in both flint and amber colors will first be considered. Typical data on mold temperatures, both blank and blow, will be given and comparisons made for the two colors of glass. Other Owens jobs will then be discussed, after which there will be a treatment of data on the Miller JPM machine. Cut-off on Owens machine or gob shear on Miller represents zero time on the data and plots.

In operating a 12 oz. beer bottle in both flint and amber glass, inside and outside blank and blow mold temperature data were taken. The positions of measurement for the blank mold are given in Figs. 6 and 7. Inside blow mold position are related to the bottle as shown in Table 7; outside blow mold positions are shown in Fig. 8.

Typical curves on amber beer molds are shown in Figs. 9, 10, and 11. Figure 9 shows a blank mold cyclical variation on front seam of approximately 210°F with a peak at the blank-open position and a minimum just before dip into the pot. The rate of rise while filling with glass is slightly less than 200°F in about 1½ seconds. The inner seam shows much less rapid rise, particularly near the bottom. The intimation is that the cooling available here must not be great enough in relation to heat from the glass to give the typical effects noted in other positions. The outside of the blank mold (Fig. 10) showed only a variation of ± 25°F on the front seam and about ± 10°F away from the seam. Positions near the nose of the blank are hotter both inside and outside. The vertical gradient is not large on the inside. It amounts to about 125°F on the outside.

The blow mold temperatures (Fig. 11 and Table 7) show a minimum as the mold closes and a temperature rise of 75 to 95°F for amber glass and from 35 to 130°F for flint glass. The position of least rise was high up on the inner seam (No. 9); the position of greatest rise was midway up and away from the seam (Table 7). In all cases amber temperatures were somewhat higher than those for flint glass, although the differences were generally much less than 100°F. The blow mold surface is not subject to the extreme rates of change which are characteristic of the blank mold surface.

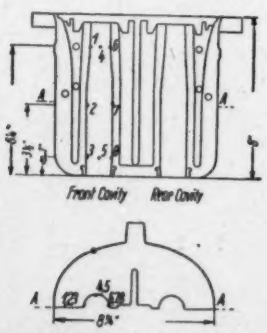


FIG. 6. Positions of blank mold inside temperature measurements on 12 oz. capacity beer—Owens operation.

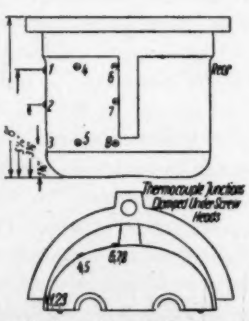


FIG. 7. Positions of blank mold outside temperature measurements, 12 oz. capacity beer—Owens operation.

The outside blow mold temperatures showed a constant temperature within 10°F as tabulated in Table 8. There is no definite relationship when comparing flint and amber, although the latter generally gave slightly lower temperature data. This seems contradictory to the higher inside mold temperatures for amber operation.

Curves for imbedded thermocouples (see Section 2.3) positioned against the mold metal 1/16 inch back from the inner surface of the blank are not presented. The data are summarized in Table 9.

At the position near the top of the blank, the variation from maximum to minimum was from 15 to 25°F; at the bottom of the blank it was 35 to 40°F. Even though the inside blank mold temperatures near the nose were hotter for flint than for amber operation, the imbedded couple results were slightly lower. This indicates a different thermal gradient within the metal for the two glass colors. During a large portion of the cycle the inside surface temperature is lower than the imbedded temperature. Heat is flowing to both surfaces of the blank mold in this case, and a reversal of heat flow is made during each cycle. The nose of the blank mold at the position of the imbedded thermocouple runs about 100°F hotter than at the position 6⅛ inches above the nose.

4.2. Comparisons of Glass and Mold Temperature Data

Summaries of glass temperature data for the amber and flint beer bottles have been given in Tables 1 and 2. A comparison now to be made concerns the differences in temperature between glass and blow mold. The same positions are not always available, but they are close enough to allow a reasonable comparison. Table 10 shows these differences between glass and blow mold temperatures for flint and amber glass.

The first outstanding thing (see Table 10) is that amber glass averages much less difference than does flint glass throughout the cycle. The differences between amber and flint are greatest at the neck ring opening. Concerning comparison of inner and outer seams, both amber and flint show lesser difference between glass and mold temperature at the inner seam than at the outer seam.

4.3. Blank Mold Temperature Data on an Owens Single-Cavity Job

Data on one large single-cavity Owens job are being reported. This job was a typical half-gallon jug weighing 31 oz. It was a round jug with 4⅞ inches bottle diameter, 9¾ inches high, with a 1¼ inches diameter screw type lug finish. The blank was 6⅝ inches long with a 1¾ inches diameter nose. This is the same job on which glass temperatures are presented in Table 4. Blank mold temperature data are given in Table 11.

Blank mold temperatures for this large job were quite consistent and uniform. The maximum temperatures for a group of 16 thermocouples varied from 1080 to 1180°F. The gradients were quite consistent from top to nose of the blank. The blank from left to right half was within 35°F, with the left half being colder.

4.4. Summary on Owens Mold Temperatures and Related Glass Temperatures

The following statements are generalities on mold temperatures and related glass temperatures, and are based on data reported herein as well as other data not reported:

1. The horizontal temperature gradients in the blank mold, in the single-cavity jobs studied, are quite small, and there is no consistent relationship between temperatures on front seam, rear seam, and at right angles to the seams. Horizontal blank mold temperature gradients become greater in double-cavity jobs, where the inner seam usually runs the hottest. The positions at right angles to the seams are next in order, although instances where the latter are hottest have been recorded.

2. Vertical temperature gradients in blank molds are much greater than the horizontal temperature gradients, with the uppermost locations being colder than near the nose. This is not necessarily detrimental, for an equalization of temperature in the vertical plane is not desirable in Owens operation.

3. The range of temperature change to which the surface of Owens blank molds are subjected during one machine revolution varies from 95 to 255°F and is

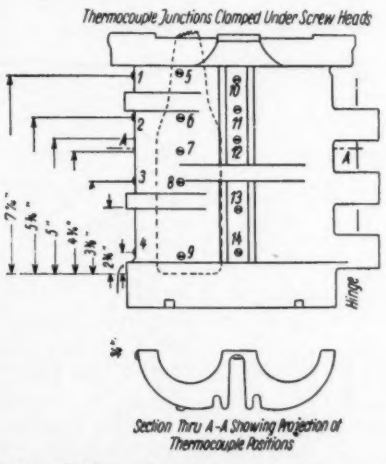

Thermocouple Junctions Clamped Under Screw Heads
Hinge
Section Thru A-A Showing Projection of Thermocouple Positions

FIG. 8. Positions of blow mold outside temperature measurements on 12 oz. capacity beer—Owens operation.

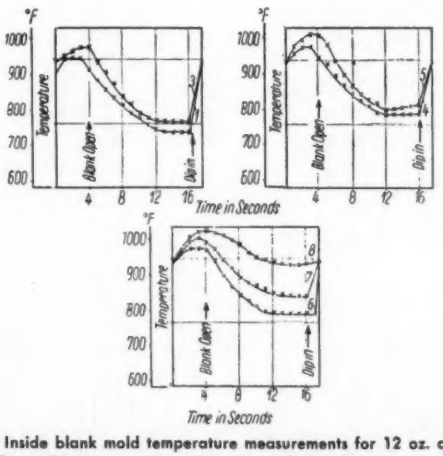


FIG. 9. Inside blank mold temperature measurements for 12 oz. capacity amber beer—Owens operation. (See Fig. 6 for positions.)

greater, in general, as the size of the job becomes greater. The maximum temperatures attained on the inside surface of Owens blank molds become greater as the weight of the bottle increases.

4. There is a semblance of correlation between inside blank mold temperatures at the blank-open time and glass surface temperatures early in the cycle. However, many exceptions are also noted.

5. When compared to flint glass, the amber glass holds to the mold surface due to its faster setting, resulting in less temperature differential between glass and mold, and definitely hotter blow molds. No definite conclusion can be made from the data regarding the relative importance of heat radiation and conduction of the glass itself when comparing amber and flint operation.

6. A very slight thickness of metal on the interior surface of the blank mold carries the greater load of differential expansion due to large cyclical temperature variations. Thus a reversal of the direction of heat flow occurs twice each cycle of operation for the blank mold. One occurs some few seconds after the blank mold opens and the other, just at the dip-in.

4.5. Blank Mold Temperature Measurements on Miller Machines

Since the Miller machine carries one-piece blank molds, one would expect an improved uniformity of mold temperature around the mold, on any horizontal section, due to the uniform metal sections and the presence of uniform heat transfer conditions. The blow molds are, of course, split. The studies to be reported below ran simultaneously with the Owens studies. Jobs studied ranged from 6 to 32 oz. capacity, 4 to 9 inches in height, 2½ to 5 inches in diameter, and weights from 7¾ to 16 oz. Gob temperatures varied from 1865 to 1960°F, as measured by thermocouple immersion technique. Speeds were from 32 to 47 per minute on the J. P. M. machine. In some cases glass temperatures or blow mold data were also taken.

Rather complete data are given for a 16 oz. and a 32 oz. round wide-mouth jar. Bottle A[g] is a 16 oz. capacity jar, 9½ oz. weight, typical of a pint shape, body diameter 3¼ inches, height 5¼ inches. Bottle B is 32 oz. capacity, 16 oz. weight, body diameter 3½ inches, height 7½ inches. The blank molds were typical taper-shaped Miller molds with heights as follows: bottle A, 3¾ inches; bottle B, 6⅛ inches.

Blank mold temperatures for bottle A and bottle B are given in Table 12. It is evident that the middle sections of these blanks are hotter than either the top or bottom sections. The differences are of the order of 40 to 60°F for the 16 oz. jars. It is nearer 100°F for the 32 oz. jar. Cyclical variations are 90 to 130°F for the smaller jar and 50 to 110°F for the 32 oz. jar. The larger jar runs hotter by 100°F or so, and its outside shows greater temperature change during the cycle. The temperature gradients through the molds are not great, but are greater for the larger job. Temperature gradients around the mold are small. Other jars from 6 to 32 oz. gave only 20°F variation around the blank mold in any selected horizontal gradient.

4.6. Blow Mold Temperatures on Miller Machines

Blow mold temperatures at specific points in the cycle are given in Table 13 for bottle A, 16 oz. round jar and for bottle B, 32 oz. round jar.

For the smaller jar the blow mold temperatures range from 900 to 1075°F maximum. Cyclical variations are from 65 to 135°F. The bottom of the mold is about 150°F colder than the top. Variations around the mold in horizontal section are of the order of 50°F at the top to 25°F at the bottom. The gradient through the mold metal is not great. The 32 oz. jar mold runs somewhat hotter than the 16 oz. mold. Its peak temperature is 1150°F. Cyclical variations do not differ from those for the small job. The gradient is greater through the mold from inside to outside.

4.7. Comparisons of Glass and Mold Temperature Data, 16 oz. Round Jar-Miller Operation

In Section 4.2 and Table 10, differences in temperature for glass and mold were compared for flint and amber beer bottles on Owens operation. A comparison of such differences for a 16 oz. Round Jar on Miller operation is given in Table 14. The differences are of the order of:

800°F	at 2nd blow release
to 600-700°F	at 3rd blow release
to 400-500°F	at delivery.

g. This is a different job from that for which glass temperatures are reported in Section 3.7 and Table 6.

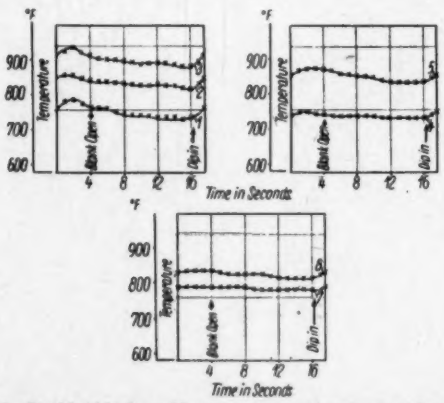


FIG. 10. Outside blank mold temperature measurements for 12 oz. capacity amber beer—Owens operation. (See Fig. 7 for positions.)

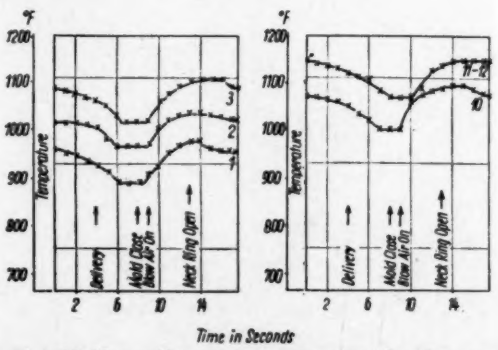


FIG. 11. Inside blow mold temperature measurements for 12 oz. capacity amber beer—Owens operation. (See Table 7 for positions.)

Table 7

INSIDE BLOW MOLD TEMPERATURE DATA, 12 OZ. FLINT AND AMBER BEER OWENS OPERATION

No.	Position	Inches Up From Bottom of Bottle	Metal Thickness (Inches)	Temperature °F Flint Min.	Flint Max.	Amber Min.	Amber Max.
1	Front seam	6¼	1.10	815	900	890	980
2	" "	4⅞	.75	910	990	965	1035
3	" "	3¼	.75	980	1025	1020	1105
4	" "	1	.7	—	—	—	—
5	90° to seams	7½	1.4	775	835	—	—
6	" " "	4⅞	1.2	835	915	—	—
7	" " "	3¼	1.0	860	990	—	—
8	" " "	1	1.0	—	—	—	—
9	Inner seam	6	1.0	900	935	—	—
10	" "	4½	.5	975	1060	1005	1100
11	" "	3½	.5	1035	1140	1075	1150
12	" "	1¼	1.0	—	—	1075	1150

Table 8

OUTSIDE BLOW MOLD TEMPERATURE DATA, 12 OZ. FLINT AND AMBER BEER, OWENS OPERATION

Location	Pos. No.	Inches Up From Bottom of Bottle	Metal Thickness (Inches)	Temperature °F Flint	Amber
Front seam	1	7¼	1.3	710	—
" "	2	5¾	0.75	820	885
" "	3	3⅜	0.75	950	810
" "	4	¾	0.7	860	660
90° to seams	5	7½	1.4	660	—
" " "	6	5¾	1.1	740	—
" " "	7	4¾	1.0	—	650
" " "	8	3⅜	1.0	810	—
" " "	9	5/16	1.0	745	665
Cooling slot	10	7¼	2.5	560	—
" "	11	6	0.4	715	—
" "	12	5	0.3	—	810
" "	13	2½	0.3	930	925
" "	14	¾	2.0	490(?)	—

Table 9

BLANK MOLD TEMPERATURES 1/16 INCH BEHIND THE INNER SURFACE FOR FLINT AND AMBER GLASS COMPARED TO INSIDE SURFACE MEASUREMENTS (IMBEDDED THERMOCOUPLES)- 12 OZ. BEER - OWENS OPERATION

Position	Glass	Inside Blank Mold Temperature °F Min.	Inside Blank Mold Temperature °F Max.	Imbedded Blank Mold Temperature °F Min.	Imbedded Blank Mold Temperature °F Max.
90° to seam 6⅛ in. above cutoff	Flint	785*	967*	800	825
	Amber	780	970	820	835
90° to seam 1 in. above cutoff	Flint	850*	1105*	900	935
	Amber	790	1025	920	965

* Nearest position measured.

These differences are greater than for the Owens operation, due presumably to the station-cycle type of blowing. The air pressure is on for a short time and then released for the mold to move to the next station.

4.8. Summary of Miller Mold Temperatures and Related Glass Temperatures

A generalized series of statements about Miller mold temperatures is as follows, based on data reported herein and other data not reported:

Table 10

DIFFERENCES IN TEMPERATURE BETWEEN GLASS AND BLOW MOLD FOR FLINT AND AMBER BEER - OWENS OPERATION

Position in Cycle	Position on Mold	Temperature Difference, °F Mold-Glass Flint	Amber
2 seconds after blow air is applied	Front seam 6¼ in. up on bottle	620	415
	Front seam 4⅞ in. up	460	480
	90° to seam 3¼ in. up	570	—
	Inner seam 4½ in. up	505	340
	Inner seam 3 1/6 in. up	535	425
At neck ring opening	Front seam 6¼ in. up	465	245
	Front seam 4⅞ in. up	445	240
	90° to seam 3¼ in. up	475	—
	Inner seam 4½ in. up	435	120
	Inner seam 3½ in. up	340	150
At delivery from mold	Front seam 6¼ in. up	205	180
	Front seam 4⅞ in. up	205	155
	90° to seam 3¼ in. up	340	—
	Inner seam 4½ in. up	205	50
	Inner seam 3½ in. up	145	95

1. The blank molds and blow molds which are used on the Miller machine are single cavity and uniform in horizontal section, and thus have quite even temperature distribution over these sections. The one-piece blank molds, not being split halves, have even more uniform temperature gradients, with regard to the vertical and horizontal contours, than do the blow molds.

2. The Miller blank molds have a more uniform horizontal and vertical temperature distribution over the inside surface than do Owens blank molds. Moreover, the temperature changes to which the inside surfaces of the molds are subjected are much less for Miller molds.

3. For the larger sizes of Miller-made ware, the hottest position in the blank mold is usually about three-fourths of the way down from the top of the cavity. This conforms very closely to the edge of the inside surface area in contact with the gob while the latter is lying in the blank mold prior to pressing. Thus, if attempts were made to minimize the settle wave by increasing the temperature of a portion of the blank, that portion concerned would correspond closely with the area which is already the hottest inside surface of the blank.

4. Blank molds for smaller Miller jobs are more uniform in temperature through their vertical section than are the larger jobs.

5. Due to the intermittent application of blow air in Miller operation, the glass-metal temperature differences are high compared to Owens operation.

5. Review of Glass and Mold Temperature Techniques

The actual data on glass and mold temperatures have been summarized in the body of the report and need not be repeated here. The reader can make more comparisons than have been directly made in the report by choosing appropriate data from different segments. The temperature measuring techniques which have been developed are also reviewed.

Table 11

INSIDE BLANK MOLD TEMPERATURES ON HALF-GALLON JUG - OWENS OPERATION

No.	Position	Distance In. Up From Nose	Distance In. Down from Parting Line	Thickness of Metal (Inches)	Temperature °F Max.	Min.	Diff.	Cutoff (0.0)	Blank Open (3.6)	Blank Cooling (8.0)
					(Right Half)					
1	Front	6.5	0.3	3.3	1085	910	175	1020	1070	940
2		4.6	2.1	3.0	1115	930	185	1050	1100	970
3		2.5	4.3	3.0	1150	965	185	1110	1150	1000
4		0.8	6	2.3	1170	1005	165	1150	1165	1045
5	90°	6.5	0.3	3.3	1120	940	180	1000	1110	970
6		4.6	2.1	3.0	1140	950	190	1110	1120	995
7		2.5	4.3	3.0	1160	990	150	1120	1150	1030
8		0.8	6	2.3	1180	1010	170	1140	1180	1030
9	Rear	6.5	0.3	3.3	1080	890	190	990	1070	935
10		4.6	2.1	3.0	1115	935	180	1075	1100	980
11		2.5	4.3	3.0	1130	960	170	1070	1130	1005
12		0.8	6	2.3	1145	970	175	1080	1145	1015
					(Left Half)					
1	Front	0.8	6.0	2.3	1135	960	175	1080	1135	1005
2	90°	6.5	0.3	3.3	1085	900	185	985	1085	940
3	90°	2.5	4.3	3.0	1125	925	200	1070	1110	970
4	Rear	0.8	6.0	2.3	1130	970	160	1090	1130	995

Some very satisfactory techniques for the measurement of glass and mold temperatures during forming have been described. These have included a method for placing a small diameter (.012 inch) preheated bare thermocouple assembly within a mold just prior to blowing, so that the glass surface blows around the wires. The wires adhere and have about 50 to 70 per cent surface contact with the glass. Contact with the mold is only at a tangent to the small wire diameter. Oxide on both the mold and the thermocouple wire prevents any short-circuiting of the emf effects. This factor was tested with various degrees of pressure between wire and mold in a preliminary laboratory setup.

Table 12

INSIDE AND OUTSIDE BLANK MOLD TEMPERATURES FOR A 16 OZ. CAPACITY JAR, COMPARED TO A 32 OZ. CAPACITY JAR - MILLER OPERATION

Position	Up from Valve of Blank, In.	Inside Blank Mold Temperature °F Min.	Max.	Outside Blank Mold Temp. °F
		Bottle* A: 16 oz. Capacity		
Front Side	3.3	780	870	770-775
	2.1	800	930	790-800
	0.8	760	860	765-765
Rear Side	3.3	800	890	730-740
	2.1	830	950	760-760
	0.8	780	880	740-740
		Bottle* B: 32 oz. Capacity		
Front Side	5.9	870	980	725-760
	4.1	935	1025	820-845
	2.5	970	1050	875-890
	0.8	890	1000	820-840
Rear Side	5.9	850	945	765-795
	4.1	885	970	—
	2.5	935	1010	890-900
	0.8	875	990	—

* See Section 4.5 for description of Bottles A and B.

The conditions were such as to satisfy as nearly as possible the theoretical requirements of immersion within a constant temperature for a thermocouple procedure.

A second procedure for spot welding thermocouples within the surface of any mold or metal was proven to give useful comparative results. The assembly gives little disturbance to normal heat flow within the mold,

Table 13

INSIDE AND OUTSIDE BLOW MOLD TEMPERATURES FOR A 16-OZ. CAPACITY JAR, COMPARED TO A 32-OZ. CAPACITY JAR - MILLER OPERATION

Position	Up from Bottom, Inches	Inside Blow Mold Temperature, °F Min.	Max.	Outside Blow Mold Temperature, °F Min.	Max.
		Bottle A: 16 oz. Capacity			
Front Seam	3.4	965	1070	860	885
	1.9	900	985	835	860
	0.4	810	900	760	770
90° to Seam	3.4	960	1020	—	—
	1.9	880	945	860	865
	0.4	815	910	775	775
Rear Seam	3.4	940	1075	815	840
	1.9	885	980	775	815
	0.4	785	900	815	815
		Bottle B: 32 oz. Capacity			
Front Seam	6.3	1005	1060	835	870
	4.6	1000	1085	840	870
	2.6	970	1070	815	840
	0.6	895	1015		
90° to Seam	6.3	1080	1150	—	—
	4.6	1030	1105	—	—
	2.6	995	1090	905	920
	0.6	925	1025	855	865
Rear Seam	6.3	955	1035	870	885
	4.6	965	1065	—	—
	2.6	980	1090	910	920
	0.6	—	—	850	860

Table 14

DIFFERENCE IN TEMPERATURE BETWEEN GLASS AND BLOW MOLD FOR FLINT 16-OZ. ROUND, MILLER OPERATION—BOTTLE A

Position	Up from Bottom, Inches	Temperature Difference, Mold-Glass, °F: At Second Blow Release	At Third Blow Release	At Delivery
Front Seam	3.25	670	560	430
	2.0	795	670	410
	1.0	795	690	505
90° to Seam	3.25	770	675	425
	2.0	820	715	545
	1.0	800	730	580
Rear Seam	3.25	645	575	450
	2.0	815	715	480
	1.0	815	720	525

but the wires are not placed within an isothermal plane. The heat loss from the junction back along the wires must be comparable to that in the mold body itself. In addition, of course, the removal of metal for the wire insertion tends to increase the response from the thermocouple junction.

Methods of assembly of mold thermocouples have been improved by Babcock and McGraw[4], who have also used the latest recording instruments. Methods of glass temperature measurement remain today essentially as originally developed.

Another measuring tool used during the initial stages of the work was a compensated type contact pyrometer. In this instrument the head is heated to the expected temperature of the glass surface, after which contact is made with the surface. When the surface is hotter than the head, heat flows from the surface to the head, upon contact. The reverse situation is also possible. The direction of heat flow is determined by a sensitive differential couple resulting from two junctions—one on the surface and one 0.020 inch behind the surface, using a galvanometer as an indicating instrument. When the compensated couple is balanced to the surface temperature, no heat flow is attained, and the temperature of the head is read at leisure by a second instrument. This device was found useful for early glass surface temperatures, as well as for temperatures of glass surfaces after discharge of the glass article from the mold. It does, however, stick at high temperatures, and is also very sensitive to windy conditions which cool the head.

A subsequent very useful development for control purposes, not covered in this report, was that of a radiation type instrument reading an area of .144 inch diameter, at a point in the cycle where the mold was open and where sighting could be continued for three seconds to give 98 per cent response. This head was used with a gold-plated sighting tube 12 inches long and was inserted and held by hand, thus following the machine rotation, for the necessary time. Only one spot reading was possible, but the apparatus was useful on operating machines without disturbing production or without connections to the machine. Every mold half on the machine could be measured within a period of 35 to 40 revolutions. Balance from mold half to mold half, or from head to head, was thus determined. A sensitive galvanometer of proper period and resistance was used as an indicating instrument.

6. Summary

Methods and procedures have been developed for measuring surface glass temperatures within the blow mold. Similarly, methods for measuring surface temperatures, both inside and outside, on both blank molds and blow molds, are given. An experimental investigation of such temperatures on Owens and Miller operation in relation to flint and amber glass, variations of temperatures over the glass and the mold, and other important variables, is described.

The temperatures of glass as it goes to the Owens and Miller machines are presented in order to arrive at the beginning of the working range. It is shown that the viscosity range for Owens operation is from log 2.7 to 3.8 at the time of fill of the blank mold by vacuum. For the relatively stubby gob which is characteristic of Miller press-and-blow operation, the viscosity of the glass as it hits the mold ranges from log 3.7 to log 4.1. A concept of the end of the working range based on deformation of the bottle after delivery from the blow mold is shown to be consistent with bottle shape and wall thickness. The lower end of the working range conforms to the maximum temperature of the glass surface, at any portion of the bottle, to which the surface must be cooled to avoid deformation of the bottle upon discharge from the machine.

On this basis, round Owens bottles gave log 7.1 to log 7.7 as the lower end of the working range. For flat, thick sections in whiskey flasks, the temperature must be lower, corresponding to log 8.8. For thinner wide-mouth Miller ware, the lower end of the working range is at log 6.1 to log 7.2.

Broadly, glass temperature curves for both Owens and Miller operation do not differ to any appreciable degree. Such differences as do exist are related to the general expected characteristics of the two processes. Miller ware gives lower surface cooling rates in the blow mold and does not have to be so cold upon delivery to avoid deformation. Miller glass temperatures show less breaks in the cooling curves than do Owens glass temperatures. Conditions of extremely rapid surface glass cooling result from amber glass in Owens operation. These extremely rapid cooling rates, when compared to flint ware, result in a high gradient through the thickness of glass. Upon leaving the blow mold, such surfaces are subject to more or less erratic behavior—as distinct from normal continuous cooling—presumably due to partial equalization of glass temperature from outside surface to interior of the glass section and on to the interior glass surface.

The cavity areas in close proximity to each other in a double-cavity blank mold on Owens operation are the hottest of the entire inner surfaces. Positions near the nose—the area which contacts the glass surface in the revolving pot—are hotter than areas further up the blank. Usually the gradient in a vertical direction up the blank is quite regular to the position near the neckring parting line, which is coldest. Single-cavity blanks have a more desirable temperature condition than double-cavity blanks. The most uniform horizontal temperature con-

(*Continued on page* 181)

RARE EARTHS in the Glass Industry

by Clifford A. Hampel, CONSULTING CHEMICAL ENGINEER, SKOKIE, ILL.

(Conclusion of a three part article.)

The applications in the glass industry of the rare earths other than cerium*. These rare earths have unique properties which have resulted in their use in compound form in the glass industry. As might be expected, the amount of each rare earth used is related to availability and cost, and to its relative commercial prevalency in the ore from which each is derived.

These factors were discussed in the first article of this series (see* THE GLASS INDUSTRY, *41, No. 1, 14, Jan. 1960). As shown in Table III of that article, the order of production capacity for the rare earths (expressed as oxides) is cerium, lanthanum, neodymium, praseodymium, samarium, gadolinium, dysprosium and erbium, followed by the rest of the series in much smaller amounts. This is the same sequence as that of the concentration of these elements in the monazite and bastnasite ores that are the source of all except a minor fraction of these elements.

● XENOTIME, ANOTHER SCARCER MINERAL, while chiefly a source of yttrium, contains higher quantities of the rare earths—from gadolinium through lutetium (atomic numbers 64-71)—than do either monazite and bastnasite. This is the raw material from which is obtained much of the rather small production of terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium, all of which are now available. Xenotime, for example, is the material being processed in the rather extensive ion exchange operation at the present time at Iowa State University, Ames, Iowa. An analysis of a typical xenotime concentrate is given in Table I.

The relative quantities of yttrium and the rare earths that could be produced depends somewhat on the natural prevalency of these elements in the earth's crust. In Table II, the sequence of these elements is listed in decreasing order of occurrence, along with a second listing in increasing order by atomic number. The concentration in the earth's crust is given in parts per million or grams per ton.

It will be noted that those rare earths of even atomic numbers are much more abundant than those of odd atomic numbers; in fact, the sum of the concentrations of the even-numbered rare earths is about four times that of the odd-numbered ones. It will also be noted that the lighter rare earths (atomic numbers 57-64) are much more abundant than the heavier rare earths (atomic numbers 65-71).

* Cerium was discussed in THE GLASS INDUSTRY, *41*, No. 2, 82, Feb. 1960.

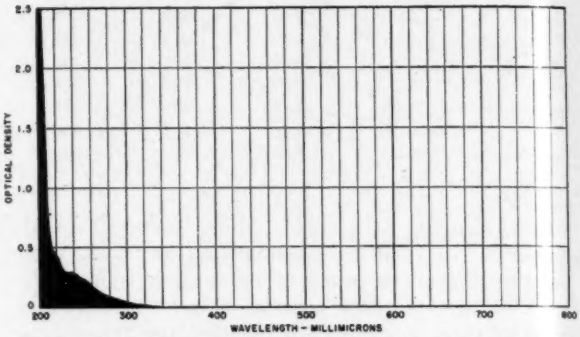


FIG. 1. Absorption spectrum of lanthanum chloride solution. Contains 2 g. La_2O_3/100 ml. compared with water in 5 cm. cells.

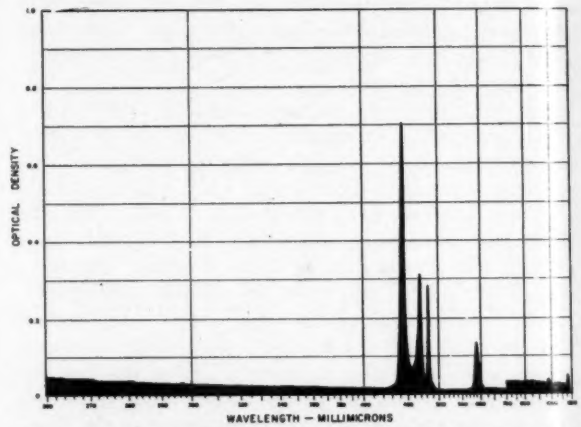


FIG. 2. Absorption spectrum of praseodymium perchlorate solution. Contains 1% Pr_6O_{11} (99.9% pure) compared with water in 1 cm. cells measured with Beckman DK-2 Ratio Recording Spectrophotometer.

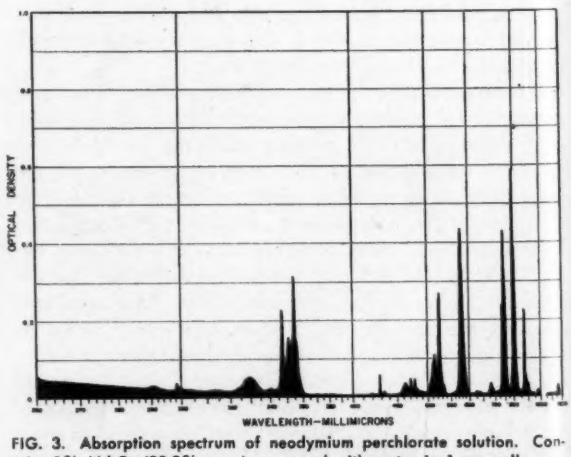


FIG. 3. Absorption spectrum of neodymium perchlorate solution. Contains 1% Nd_2O_3 (99.9% pure) compared with water in 1 cm. cells.

These factors have been important, of course, in establishing the commercial availability of the individual rare earths. The fact that monazite and bastnasite are much more available than other rare earth ores in the form of large mineral deposits—and hence are the chief sources of the rare earths—has resulted in the commercial availability of these elements matching closely their order of natural prevalence.

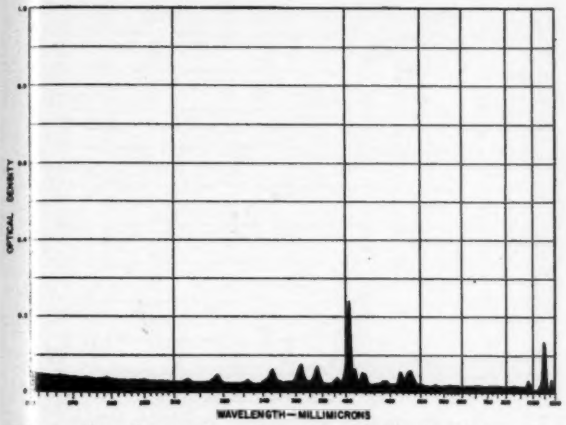


FIG. 4. Absorption spectrum of samarium perchlorate solution. Contains 1% Sm_2O_3 (99.9% pure) compared with water in 1 cm. cells.

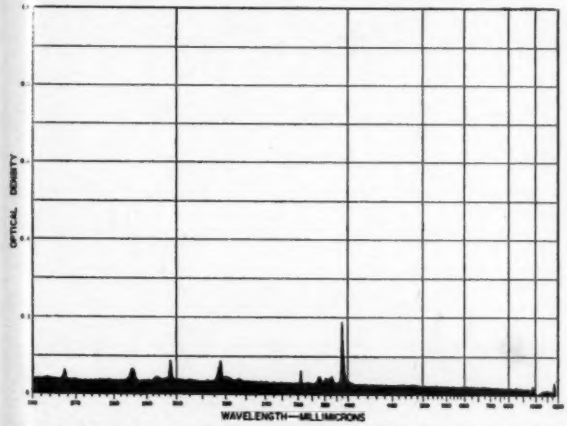


FIG. 5. Absorption spectrum of europium perchlorate solution. Containing 1% Eu_2O_3 (99.8% pure) compared with water in 1 cm. cells.

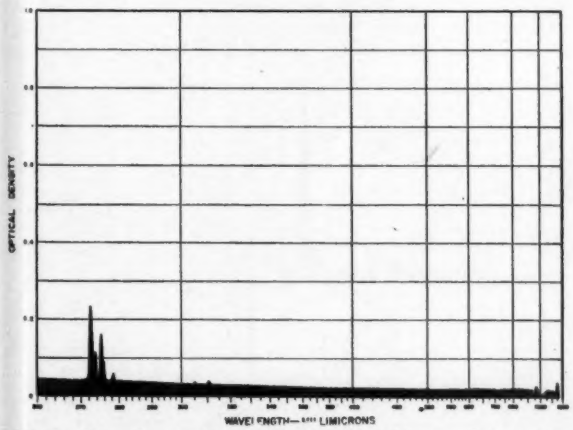


FIG. 6. Absorption spectrum of gadolinium perchlorate solution. Containing 1.09% Gd_2O_3 (99.9% pure) compared with water in 1 cm. cells.

Table I

XENOTIME CONCENTRATE COMPOSITION

85% GRADE

Atomic Number	Compound	Per Cent
	ThO_2	0.46
	U_3O_8	0.74
	R_2O_3	55.4
	P_2O_5	28.3
39	Y_2O_3/R_2O_3	65.0
62	Sm_2O_3/R_2O_3	1.7
63	Eu_2O_3/R_2O_3	0.055
64	Gd_2O_3/R_2O_3	4.0
65	Tb_4O_7/R_2O_3	1.25
66	Dy_2O_3/R_2O_3	8.6
67	Ho_2O_3/R_2O_3	2.0
68	Er_2O_3/R_2O_3	7.2
69	Tm_2O_3/R_2O_3	1.0
70	Yb_2O_3/R_2O_3	6.0
71	Lu_2O_3/R_2O_3	0.8
	Other R_2O_3	2.4

R_2O_3 = Total rare earth oxides.

Source: Bulletin, *Rare Earth Chemicals, Thorium, Heavy Minerals*, Heavy Minerals Co., Chattanooga, Tenn.

Table II

AVERAGE AMOUNTS OF YTTRIUM AND RARE EARTHS IN THE EARTH'S CRUST IN PARTS PER MILLION OR GRAMS PER TON

In Order of Decreasing Concentration			In Order of Increasing Atomic Number		
Atomic Number	Element	PPM	Atomic Number	Element	PPM
58	Ce	46	39	Y	28
39	Y	28	57	La	18
60	Nd	24	58	Ce	46
57	La	18	59	Pr	5.5
62	Sm	6.5	60	Nd	24
64	Gd	6.4	61	Pm	*
59	Pr	5.5	62	Sm	6.5
66	Dy	4.5	63	Eu	1.1
70	Yb	2.7	64	Gd	6.4
68	Er	2.5	65	Tb	0.9
67	Ho	1.2	66	Dy	4.5
63	Eu	1.1	67	Ho	1.2
65	Tb	0.9	68	Er	2.5
71	Lu	0.8	69	Tm	0.2
69	Tm	0.2	70	Yb	2.7
			71	Lu	0.8

* Promethium not found naturally, but appears in fission products of atomic reactors.

Properties of Rare Earth Oxides

Inasmuch as almost all of the rare earths used in the glass industry appear in the form of oxides in the final product the physical properties of the rare earth oxides are of importance. Many of these are summarized in Table V. The fact that the table is incomplete indicates the need for more studies on the basic properties of rare earth compounds. Such work has been stimulated in recent years by the growing availability of pure compounds of the individual rare earths. Studies have been made at the several atomic energy laboratories interested in the application of the very high thermal neutron cross sections of samarium, europium, gadolinium and dysprosium for control rods or nuclear poisons in nuclear reactors.

The availability of high-purity individual rare earth compounds is a development of the past five years and accounts for the lack of knowledge about their properties.

In addition to the data in Table V, the free energies, heats of formation, and entropies of the cerium earth oxides (La, Ce, Pr, Nd and Sm) are presented by Brewer.[5]

Radiation Absorption Spectra

The rare earth compounds, with the exception of those of lanthanum, lutetium and yttrium, exhibit quite sharp absorption bands in the ultraviolet, visible and infrared portions of the radiation spectrum. These absorption bands have led to the use of several of the rare earths, either individually or as mixtures, in the preparation of glasses where they act as coloring agents, decolorizers, or filters.

The absorption spectra of the pure rare earths and of certain mixtures of rare earths are given in Figs. 1-13. These spectra have been determined on slightly acid aqueous chloride or perchlorate solutions, using 1 cm cells for the Beckman DK-2 spectrophotometer and 5 cm cells for the Carey spectrophotometer. All measurements were made against water as a reference standard.

Absorption spectra of the rare earths are due to energy transitions in the shielded 4f orbital electrons and are relatively independent of the chemical environment of the ions. In this they differ from the transition elements.

Thus, other compounds of the rare earths show spectra generally similar to those used for these measurements. In glasses the rare earths also demonstrate essentially the same absorption properties, although there may be some slight shifts of specific absorption bands to lower or higher wave lengths.

This similarity is shown by Fig. 14, a typical spectral transmittance curve for a neodymium glass (Corning Glass Works Filter No. 5120). Comparing it with Fig. 3, (neodymium perchlorate solution containing one per cent Nd_2O_3) it will be seen that the four major peaks between 400 and 700 millimicron wave lengths in Fig. 3 match closely the four major dips in Fig. 14.

The infrared absorption spectra of some rare earth glasses have been described by Stair and Faick (6). Praseodymium glass shows two strong bands at 1.45 and 1.90 microns, with weaker bands at 0.76 and 1.0 micron. Neodymium glass shows three strong bands at 0.77, 1.63 and 2.43 microns.

In connection with Fig. 12 (absorption spectrum of didymium chloride solution) the principal rare earth absorption bands for didymium are tabulated in Table III.

Glass Industry Applications

At the present time glasses containing single or mixed rare earth compounds other than cerium are not produced in more than minor quantities. As stated previously, economical factors have hindered both increased usage and extensive research and development programs aimed at evaluating the possibilities of greater application for these compounds. The recent increase in availability of pure, single rare earth compounds and the decrease in the price of the whole series in general should encourage greater utilization of the rare earths.

The current uses are for coloring, controlling transmittancy, refractive index, and dispersion characteristics. Another that may develop with increasing construction of nuclear power plants is the preparation of glasses containing rare earths of high thermal neutron cross sections for control rods.

Colored Glasses

One of the most beautiful colors in glass is obtained by the use of pure neodymium oxide to make the only

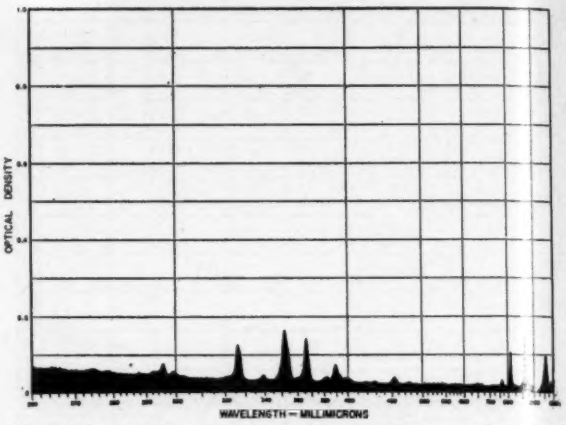


FIG. 7. Absorption spectrum of dysprosium perchlorate solution. Containing 1% Dy_2O_3 (99.9% pure) compared with water in 1 cm. cells.

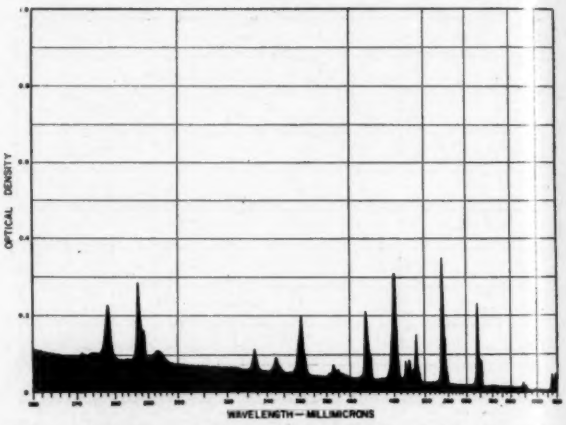


FIG. 8. Absorption spectrum of holmium chloride solution. Containing 1.25% Ho_2O_3 (99.9% pure) compared with water in 1 cm. cells.

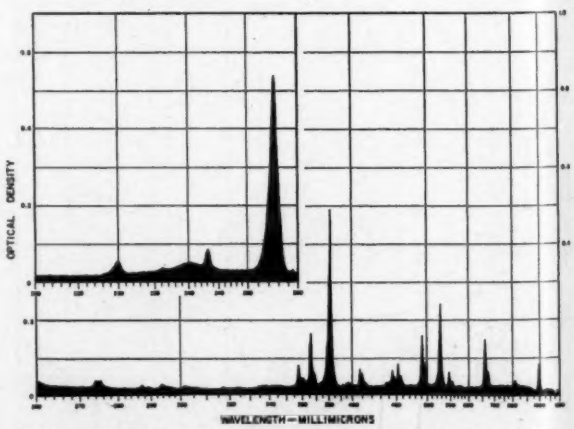


FIG. 9. Absorption spectrum of erbium perchlorate solution. Containing 1.25% Er_2O_3 (99.9% pure) compared with water in 1 cm. cells.

bright purple glass known. Neodymium oxide is present to the extent of 4 to 5 per cent in the famous purplish-blue Alexandrite glasses of Bohemia. As described by Kreidl[7], the main absorption bands for neodymium are in the green-yellow portion of the spectrum, so that the spectrum visible through this glass is divided abruptly into a blue part and a red part. This factor results in different color sensations; by varying the thickness of the glass in different sections, either by deliberate molding, or by cutting designs of varying depth in the glass wall, a play of blue and red colors is attained.

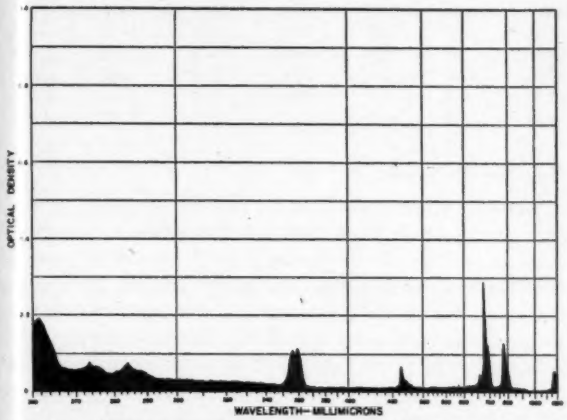


FIG. 10. Absorption spectrum of thulium chloride solution. Containing 2.19% Tm_2O_3 (99.9% pure) compared with water in 1 cm. cells.

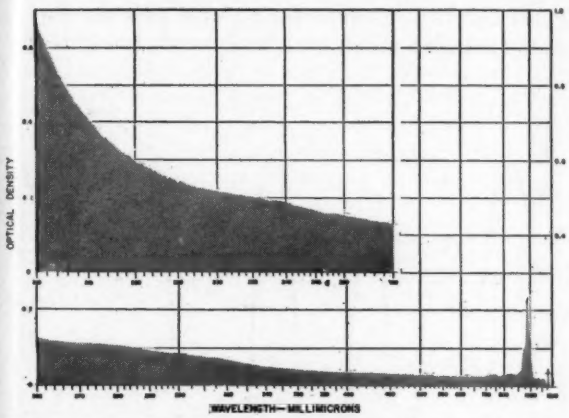


FIG. 11. Absorption spectrum of ytterbium perchlorate solution. Containing 2.06% Yb_2O_3 (99.9% pure) compared with water in 1 cm. cells.

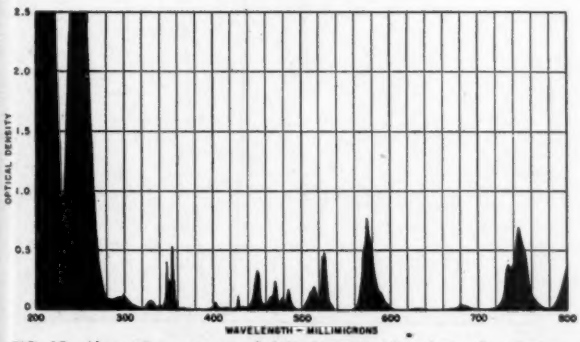


FIG. 12. Absorption spectrum of didymium chloride solution from monazite containing 1 g. rare earth oxide/100 ml. compared with water in 5 cm. cells.

This same discontinuity in light transmission between the blue and the red permits one to distinguish more easily such colors as red and green. Neodymium glass is used, because of this phenomenon, in navigation and aviation[8], and in lenses for incandescent light fixtures for rooms where the accentuation of flesh tones and food colors is desired. This glass has been sold under the trade name, Neophane (Philiphane in Holland)[9, 10].

Additional use of the high absorption of the yellow part of the spectrum by neodymium glass is made in other ways. Since neodymium absorbs the yellow sodium line of 589 millimicron wave length, windows made of neodymium glass will cause rooms or objects illuminated by sodium vapor lamps to be invisible[11]. This property can be applied to an operating room illuminated with sodium vapor lamps so that the operation may be checked with a fluorescent x-ray screen while the room is still bright. In place of the usual heavy lead glass to absorb x-rays, a lead glass colored with neodymium oxide is used in conjunction with the fluorescent screen. Under sodium light the screen then looks dark under the neodymium glass and scintillates only when excited by the x-rays.

Under fluorescent light, which contains relatively intense green and blue colors, the blue color is filtered out by glass containing neodymium oxide, leaving a predominantly green color.

For the above applications relatively pure grades of neodymium oxide are used.

Didymium products, which contain other rare earths (except cerium), as well as neodymium, can also be used to provide the light absorbency of neodymium. The so-called didymium glass is an excellent filter for the yellow sodium light and has long been used in goggles for welders and glassblowers. The presence of praseodymium in didymium products contributes a green color that is complementary to the neodymium pink color, so that didymium glass sometimes has a gray color.

Praseodymium itself gives a glass of distinctive green color, but more economical agents are available for this purpose.

Table III

PRINCIPAL ABSORPTION BANDS FOR DIDYMIUM COMPOUNDS

Wavelength (mμ)	Rare Earth	Relative Intensity	Wavelength (mμ)	Rare Earth	Relative Intensity
220	Pr	very strong	428	Nd	weak
250	Nd	very strong	445	Pr	strong
260	Nd	very strong	462	Nd	weak
292	Nd	very weak	469	Pr	strong
298	Nd	weak	470	Nd	weak
326	Dy	weak	476	Nd	weak
328	Nd	weak	479	Nd	weak
346	Nd	moderate	482	Pr	strong
350	Nd	moderate	510	Nd	moderate
351	Dy	moderate	513	Nd	moderate
354	Nd	strong	523	Nd	strong
365	Dy	moderate	576	Nd	very strong
388	Dy	weak	589	Pr	moderate
402	Sm	strong	679	Nd	weak
409	Sm	weak	732	Nd	strong
416	Sm	weak	742	Nd	very strong
420	Nd	very weak	793	Nd	very strong

All didymium materials will show this spectral absorption, even when observed on light reflected from the sample surface.

Note: The rare earths praseodymium, neodymium, and samarium are the predominant colored rare earths in didymium compounds.

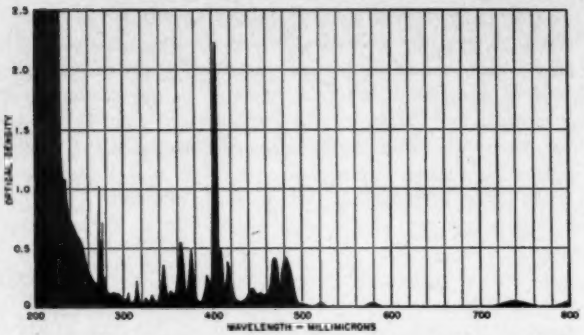


FIG. 13. Absorption spectrum of mixed samarium-gadolinium chloride solution. Containing 2 g. rare earth oxide/100 ml. compared with water in 5 cm. cells.

Decolorizing

The use of a mixture of rare earths containing cerium for glass decolorizing has been discussed in a previous article (THE GLASS INDUSTRY, *41*, p. 82, Feb. 1960). Cerium oxide in this mixture oxidizes the divalent iron, and the neodymium compensates for the yellow color of trivalent iron. This combination, for chemical and physical reasons, is one of the best decolorizers known, but price considerations and the difficulty of introducing a new material have deterred its general application[7].

Optical Glass

Lanthanum oxide in optical glass increases the index of refraction and is used in silica-free and low-silica optical glass having a high index of refraction and low dispersion. This type of glass is used for components of lenses in higher-priced cameras and in aerial photography.

The dispersion and refractivity of optical glasses are usually compared by plotting the reciprocal relative dispersion,

$$\nu = \frac{n_D - 1}{n_F - n_C},$$

against the refractive index at the wave length of the sodium D line (589.3 mu). High values of ν sometimes called the Abbe number, represent relatively low dispersions. Lanthanum borate, modified by barium oxide, may be considered the basis of modern complex no-silica and low-silica glasses of high index and low dispersion, according to Brewster, Kreidl and Pett[12]. For example, a glass containing 59.4 mol. per cent B_2O_3, 34.9 BaO, and 5.7 La_2O_3 has values of $n_D = 1.681$ and $\nu = 55.9$. Barium and lanthanum oxides cause comparatively less decrease in the ν-value than other constituents which impart equal increases of refractive index to high-index, low-dispersion crown glasses.

Chemically these borate glasses have high solubilities. Chemical durability can be obtained, with some loss of optical properties, by additions of such agents as silica, alumina, zirconia, thorium dioxide, titanium dioxide, columbium oxide and tantalum oxide. The sacrifice of refractive index is great when silica and alumina are used; thorium dioxide would cause blackening of photographic film if present in camera lenses due to the radioactivity of thorium; and relative dispersion loss is great if TiO_2 and Cb_2O_5 are used. Thus, the use of zirconium and tantalum oxides is indicated in modern high-index glasses containing B_2O_3, La_2O_3 and BaO, and having good chemical durability[12].

More recent work by Geffcken[13] indicates that calcium oxide can be substituted for barium oxide to obtain glasses of very high refractive index and quite good dispersion values. Zirconia and silica evidently are present for chemical durability. Examples of Geffcken's lanthanum oxide glasses are given in Table IV.

Table IV

Composition						
B_2O_3	SiO_2	ZrO_2	La_2O_3	CaO	n_D	μ
41.0	6.0	6.0	30.0	17.0	1.688	55.3
39.0	8.0	6.0	30.0	17.0	1.688	54.9
37.0	10.0	6.0	30.0	17.0	1.688	54.4
43.5	4.0	1.9	43.4	7.2	1.689	55.9
39.0	6.0	6.0	36.0	13.0	1.700	54.8

Nuclear Poisons

Some work has been done on the use of certain of the rare earths which have high thermal neutron cross sections as constituents in glasses to be formed into control rods for nuclear reactors. As is well known, such control rods are literally poisons to the neutron-induced atomic fission reactions in that they decrease the neutron balance in the reactor so as to slow or stop the chain reaction. The use of glasses formed into desired shapes for proper positioning in the reactor core, and sheathed by a corrosion resistant metal to prevent corrosion and erosion of the glass, has been studied. For example, Ploetz and Day[14] propose the use of a cadmium borate glass (cadmium and boron themselves have high cross

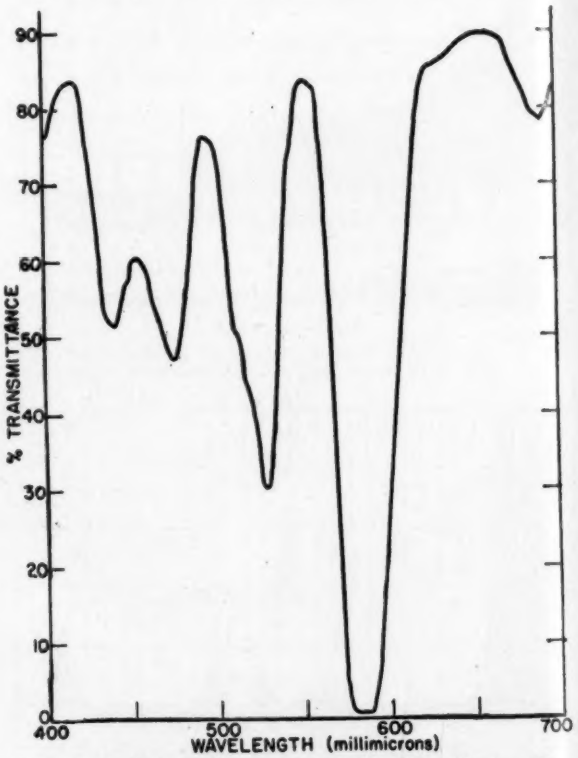


FIG. 14. Spectral transmittance of neodymium glass (Corning Glass Works Filter # 5120). Used by permission of Dr. Fay V. Tooley.

Table V

PHYSICAL PROPERTIES OF RARE EARTH OXIDES

Name	Formula	Molecular Weight	Density, g/cc	M. P., °C	Ionic Radius, Å
Yttrium oxide	Y_2O_3	225.84	4.84	2410	
Lanthanum oxide	La_2O_3	325.8	6.51	2315	1.061
Cerium oxide	CeO_2	172.1	7.3	>2600	1.034
Praseodymium oxide	Pr_6O_{11}	1021.5	6.82	.....	1.013
Neodymium oxide	Nd_2O_3	336.5	7.277	~1900	0.995
				2350	
Samarium oxide	Sm_2O_3	348.7	7.17 (2)	±50 (4)	0.979
				2050	
Europium oxide	Eu_2O_3	352.0	7.27 (2)	±30 (1)	0.950
				2350	
Gadolinium oxide	Gd_2O_3	362.5	7.64 (2)	±50 (4)	0.938
Terbium oxide	Tb_4O_7	747.7	.....	.....	0.923
				2340	
Dysprosium oxide	Dy_2O_3	373.0	8.15 (2)	±10 (1)	0.908
Holmium oxide	Ho_2O_3	377.9	.....	.....	0.894
Erbium oxide	Er_2O_3	382.5	8.64	.....	0.881
Thulium oxide	Tm_2O_3	385.9	8.6	.....	0.869
Ytterbium oxide	Yb_2O_3	394.1	9.175	.....	0.858
Lutetium oxide	Lu_2O_3	398.0	.....	.....	0.848
"Didymium oxide"		143 (avg)		2300 (approx)	

Numbers in parentheses refer to bibliography.

sections) containing rare earth oxides, such as gadolinium, samarium, eurpoium, or dysprosium oxides. The glass, after being formed, is ground and then sintered into the desired form for the reactor control rod. A typical composition is CdO, 25 per cent; Gd_2O_3, 25; B_2O_3, 30; and CaO, 20 per cent; and has a density of 4 g/cc.

Rare Earth Products

The rare earth products commercially available (other than those containing more than 1-2 per cent cerium oxide) include a wide variety of grades of compounds of the individual rare earths as well as compounds of mixtures of two or more rare earth elements. The mixtures are derived as intermediates on the process route to the production of the individual rare earths. As such they represent products lower in cost than are the individual rare earths made from them. This sequence of products has been discussed in some detail in the first article of this series.

It is to be emphasized that the availability of high purity individual rare earth compounds in recent years, due to the ion exchange techniques for obtaining them from raw materials developed by Spedding, Powell and co-workers at the Ames Laboratories and now practiced commercially, opens up new fields of application for these materials. Formerly, most of them were relatively impure or were mixtures of several rare earths. Now, modern techniques have made available what amounts

(*Continued on page* 174)

Table V (cont.)

Formula	Color	Crystal Form	Sp. heat, cal/g/°C	Thermal cond., cal/sec/cm/°C	Linear coeff. thermal expans., in/in/°C
Y_2O_3	white	cubic	0.13 (0-1600°) (3)	.....	9.3×10^{-6} (0-1400°) (3)
La_2O_3	white	hex.	0.075 (0-100°)	.....	.....
CeO_2	white	cubic	0.088 (25°)	.....	11.2×10^{-6} (0-1000°)
Pr_6O_{11}	black	cubic	.....	.....	.....
Nd_2O_3	lt. blue	hex.	.....	.....	.....
Sm_2O_3	cream	cubic	0.0944 (0-1000°) (4)	0.005 (1000°) (4)	10.8×10^{-6} (30-740°) (2)
Eu_2O_3	white	cubic	.....	.....	10.5×10^{-6} (30-850°) (2)
Gd_2O_3	white	cubic	0.0842 (0-1000°) (4)	0.005 (1000°) (4)	10.0×10^{-6} (30-850°) (2)
Tb_4O_7	brown	cubic	.....	.....	.....
Dy_2O_3	cream-white	cubic	.....	.....	8.3×10^{-6} (30-840°) (2)
Ho_2O_3	lt. yellow	cubic	.....	.....	.....
Er_2O_3	rose-red	cubic	0.065 (0-100°)	.....	.....
Tm_2O_3	greenish white	cubic	.....	.....	.....
Yb_2O_3	white	cubic	0.064 (0-100°)	.....	.....
Lu_2O_3	white	cubic	.....	.....	.....
Didymium oxide	brown				

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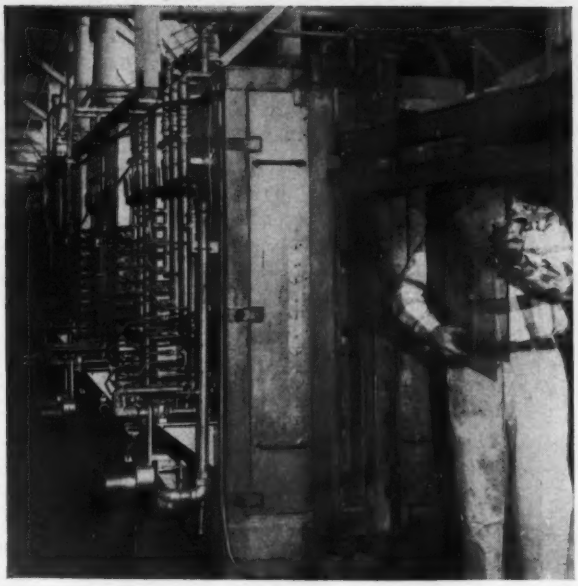

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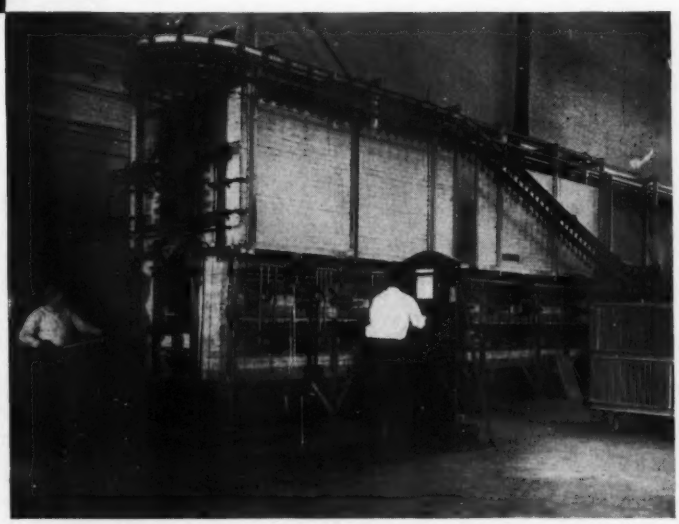
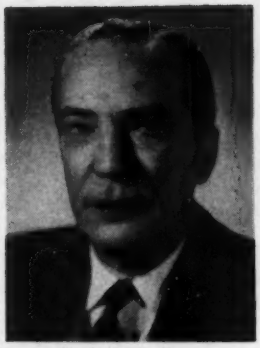


ANNEALING: Preformed glass-bonded mica sheets enter this Selas-heated, continuous lehr at far end to be conveyed through zones of increasing controlled heat. Precise preheat temperatures are essential to effect proper strength and dielectric characteristics. After final pressing, sheets take a reverse trip through upper section of lehr, through zones of decreasing heat, for annealing.

NEWS
IN THE GLASS INDUSTRY

Personalities...



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Henry S. Curtis

Benjamin L. Page

Chief of the Length Section, Optics and Metrology Division of the National Bureau of Standards. Page, who served as acting chief prior to his appointment, succeeds Dr. Lewis V. Judson who transferred to the Bureau's Office of Weights and Measures. The Length Section laboratory has custody of the national standard of length, a platinum-iridium meter bar known as Prototype Meter No. 27. Laboratory is responsible for comparing it with the various secondary line standards of length and long gage blocks which are measured in terms of the wavelength of light.

C. M. Woodruff

Manager of Canadian sales for American Nepheline Limited. Prior to his appointment he served as assistant to the vice president, sales.

E. Walter Adams, Carey E. Lindsay

Manager of Operations, eastern area plants, and production manager, eastern area plants, respectively, for Kaiser Refractories & Chemicals Division.

S. Donald Stookey

Has been issued the first patent for invention of Pyroceram glass-ceramic materials. Dr. Stookey is manager of the fundamental chemical research department, Corning Glass Works.

The invention is the most important achievement in Corning's research laboratories in 30 years and the new material has given birth to an entire new industry according to William C. Decker, president.

Calvin L. Dickinson

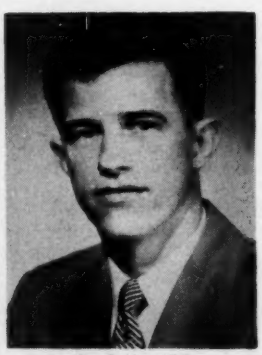
Director of manufacturing for American Potash & Chemical Corporation at Trona, Calif., and Henderson, Nevada. Henry S. Curtis continues as Henderson plant manager. Frank McGrane is manager of the company's San Francisco office.

Frank Van Kirk, Robert E. Warrick

Division process engineer for Johns-Manville Fiber Glass Division, (Toledo, O.). A newly-created position. Robert E. Warrick succeeds Van Kirk as plant manager of the Parkersburg, Wa. Va., plant.

E. Walter Adams

Carey E. Lindsay



Frank Van Kirk

Robert E. Warrick

Donald R. Martin

Research Director, Libbey-Owens-Ford Glass Company, succeeding Dr. Roy W. Wampler who retires after 30 years' service.

Dr. William J. Arner, chief of glass films research; J. Daniel Gwyn, chief of products research; Paul T. Mattimoe, chief of plastics research; and Dr. Howard R. Swift, chief of glass technology research are assistant research directors. Dr. Martin

Donald R. Martin

Harold J. Yerger

was formerly in charge of high energy fuels research for Olin Mathieson Chemical Corporation.

Richard P. Snyder

Manager of purchasing and engineering for Harbision-Walker Refractories Company. Previously served as chief engineer.

Robinson F. Barker, James F. Junge

Board Members of Pittsburgh Plate Glass Company.

Mr. Barker, vice president and general manager of the glass division, served as general manager of planning for the glass division and earlier as assistant to the president. Mr. Jungé is director of investment research and a member of the board of directors of The Pitcairn Company. He is also a director of Commonwealth Oil Refining Company of Puerto Rico.

Paul E. McCoy

Manager of product sales for Lindsay Chemical Division, American Potash & Chemical Corporation. Robert M. Curts handles sale of Lindsay products for the glass and ceramic industry.

Richard P. Snyder

Robinson F. Barker

Harold J. Yerger

Administrative assistant to Clinton F. Hegg, vice president, sales, for Libbey-Owens-Ford Glass Company. He joined the company in 1929.

Howard M. Lewis, L. James Schenck

Manager of safety glass sales and district sales manager (Toledo, O.), respectively, for Libbey-Owens-Ford Glass Company.

H. M. Lewis

L. J. Schenck

Frank M. Ryan

Retired January 29, as vice president and general manager of Norton International Inc., Norton Company's export division.

He joined the company in 1913 in what is now called the methods department, and became production engineer with Norton Company of Canada, Hamilton, Ontario, in 1919. After successive positions as holding works managers' jobs with Compagnie des Meules Norton in France and Norton's English Wheel Plant in Herts, he joined the staff of the company's European manager. Mr. Ryan returned to Worcester in 1940 as assistant to the foreign manager and was appointed assistant manager of Norton's foreign division in 1946. He was named vice president of the reorganized foreign division known as Norton Behr-Manning Overseas, Inc., in 1951, and vice president and general manager in 1957.

Mr. Ryan has been a member of the World Trade Advisory Committee for the Federal government, as appointed by the Secretary of Commerce, since 1957. He was also a member of the U. S. Government Trade Mission to Japan in 1957.

Paul E. McCoy

Frank M. Ryan

George P. MacNichol, Jr.

C. D. Jamison

Frederic C. Paffard, Jr.

Donald C. Hegnes

Frederic C. Paffard, Jr., Donald C. Hegnes

Managers, safety glass sales and warehouse sales, glass products, respectively, of Pittsburgh Plate Glass Company.

Robert E. Martin

Joined the fundamental research staff of Owens-Illinois' general research department. Dr. Martin was an associate professor of chemistry at the University of Toledo. He will concentrate on new-type polymers.

Hugh J. MacDonald

Vice president of sales, Dominion Glass Company Limited, Montreal; A. P. Colcombe, now general sales manager.

Frank Chreneik, Arthur B. Tillman

Vice president, manufacturing and general manager, respectively, Electro Chemicals Division of Diamond Alkali Company.

W. A. Weyl

Received a $56,034 grant from Glass Container Industry Research Corporation for basic studies in the process of glass molding. Project is to develop methods of measuring heat transfer at high temperatures to obtain information concerning the action of hot glass on metals. Equipment for the project includes dielectric heating equipment and an electrical induction furnace for high temperatures. Equipment is designed to simulate glass plant processes under laboratory conditions.

George P. MacNichol, Jr.

Member of the Business Advisory Council of the U. S. Department of Commerce. Mr. MacNichol, president of Libbey-Owens-Ford Glass Company, is one of seven new members named to the council to serve during 1960.

C. D. Jamison

Staff engineer to coordinate joint activities of the Research and Technical Sales Department of Harbison-Walker Refractories Company.

Carl Boyer, Jr.

Chief engineer of Minneapolis-Honeywell Regulator Company's Rubicon Instruments Division (Philadelphia). Boyer was chief evaluation engineer for Brown Instruments Division before it was acquired by Minneapolis-Honeywell.

Robert M. Lewison

Manager of the International Division of Fischer & Porter Company, manufacturers of glass products and complete process instrumentation, flowmeters, chlorination and automation equipmen

American Ceramic Society

Annual Meeting will be at the Bellevue Stratford Hotel, Philadelphia, April 24-28. A symposium on Heat Transfer Phenomena in Glass is included and the technical sessions of the Glass Division are scheduled at the Warwick Hotel.

The program committee includes: R. D. Maurer, chairman, Corning Glass Works; C. L. Babcock, Owens-Illinois Technical Center, and H. E. Simpson, State University of New York, College of Ceramics, Alfred, N. Y.

Society for Applied Spectroscopy

New York Section will meet April 5 at Stevens Institute Hoboken, N. J., and May 17, at Johnson & Johnson Laboratory, New Brunswick, N. J. The April 5th meeting includes the paper, "An Automatic Recording Spectropolarimeter", by Robert A. Bruce, Rudolph Instrument and Engineering Co. The May 17 meeting includes the paper, "Vacuum Ultraviolet Spectroscopy", by Dr. Lloyd S. Nelson, Bell Telephone Laboratories.

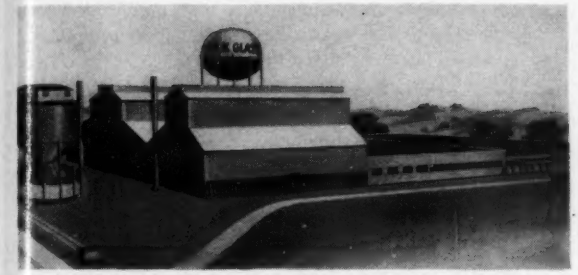
Fifth Annual Symposium

Of the American Scientific Glass Blowers Society will be held at the Penn-Sheraton Hotel, Pittsburgh, Pa.. June 15-18. A manufacturers exhibit will be included for the first time.

Technical papers will be presented on glass enamels, metallic coating on glass, metal-to-glass seal, vacuum diffusion pumps, ultra-high vacuum gauges, glass apparatus for radio isotopes, radiology, colorimetry, fractionation and distillation, quartz manipulation and mercury purification.

Information concerning booth space can be obtained from Richard Rimbach Associates, 845 Ridge Avenue, Pittsburgh 12, Pa. Information on Scientific Glass Blowing is available from the program chairman, W. W. Barr, Gulf Research & Development Co., P.O. Box 2038, Pittsburgh 30, Pa.

Companies...



Sketch of Knox Glass, Inc., new Atlanta, Ga., glass container production plant. Left to right, private railroad siding, batch plant for mixing raw materials automatically, furnace and fabricating area, annealing and inspection area, and warehousing and shipping areas.

Westinghouse Electric Corp.

Developed sealed-beam automotive back-up lamp. Lamp uses an internal non-tarnishing aluminized reflecting surface. Reflector and lens are integral parts of the glass bulb. Light reflects 20 to 30 feet, at a 50° angle from rear of auto.

Owens-Illinois Glass Co.

Became major stockholder in Compagnie Internationale de Gobelterie Inebrechable S.A., Soignies, Belgium, with the purchase of substantially all outstanding shares of the company which were bought in exchange for Owens-Illinois stock and cash. A minority stockholder since 1935, O-I now owns 97 per cent of the company's stock. Belgian firm has plants in Soignies and Manage, Belgium, and manufactures glass tumblers, stemware and related products.

Corning Glass Works

Constructing viewports for National Aeronautics and Space Administration's Mercury space capsules. Made of polished, high-temperature glass, four panes thick, they are designed to remain intact through heat and shock of re-entry.

Produced for McDonnell Aircraft Corporation, designer and builder of the man-carrying space vehicle. Viewports enable pilot to determine vehicle's altitude and take astronomical photographs.

Two outer panels of 96 per cent silica glass and two inner panes of heat resistant aluminosilicate glass compose the ports. Air space between panes retards heat transfer to inside of space capsule. The glass is ground and polished to precision finish to achieve high optical quality. Outer pane, curved to outside contour of capsule, is 21 in. high with 7½ in width at top and 11 in. width at bottom. Inner panes are flat and reduced in size to 13 in. height. Aluminosilicate glass has specific gravity of 2.53 gm/cm^3; 96 per cent silica glass is 2.18 gm/cm^3 in specific gravity.

Knox Glass, Inc.

Plans construction of multi-million-dollar plant near Atlanta, Ga., to manufacture glass containers. Designed for future expansion, it will have an initial equipment inventory consisting of two glass-melting furnaces with a daily capacity of 200 tons, a batch plant, annealing lehrs, storage and shipping areas, garages, offices and other necessary facilities. The furnaces will handle flint and amber glass. Knox intends to increase its capacity to produce both Georgia and emerald green glass.

The operation will employ about 250 men and women at a projected first year total payroll figure in excess of $1 million. The raw materials in and finished containers out will amount to the equivalent of 10 railroad box cars of materials per day.

FINANCIAL DATA

Air Reduction Co.

	1959	*1958*
Net earnings	$ 14,850,600	$ 13,349,885
Net sales	$ 200,603,636	$ 175,307,384

Johns-Manville

	1959	*1958*
Net earnings	$ 31,616,000	$ 23,374,000
Net sales	$ 377,562,000	$ 331,743,000

Knox Glass, Inc.

	1959 (Last quarter)	*1958*
Net earnings	$ 207,108	$ 185,013
Net sales	$ 9,446,190	$ 9,130,810

Libbey-Owens-Ford Glass Co.

	1959	*1958*
Net earnings	$ 53,745,152; a 151 per cent increase over 1958.	
Net sales	$ 306,734,077	$ 216,900,913

Owens-Corning Fiberglas Corp.

	1959	*1958*
Net earnings	$ 33,290,931	$ 23,377,123
Net sales	$ 211,335,854	$ 176,771,484

Owens-Illinois Glass Co.

	1959	*1958*
Net earnings	$ 40,831,354	$ 37,773,005
Net sales	$ 552,676,933; approximately a 9 per cent increase over 1958.	

Westinghouse Electric Corp.

	1959	*1958*
Net earnings	$ 85,947,000	$ 74,772,000
Net sales	$1,910,730,000	$1,895,699,000

Wyandotte Chemicals Corp.

	1959	*1958*
Net earnings	$ 4,501,545	$ 2,902,642
Net sales	$ 93,893,798	$ 82,116,603

Metro Glass Co., Inc.

Became Metro Glass Division, National Dairy Products Corporation, on January 1. Manufactures amber and flint containers, both wide and narrow neck.

Sylvania Electric Products Inc.

Will build a new electron tube research and development center at Emporium, Pa. It will be part of an intensified research program to develop new tubes to meet increasing demands of the entertainment, industrial and military markets and to improve performance and life of existing tube types.

The company opened a new 190,000 sq. ft. receiving tube plant at Altoona, Pa., in October, 1958, and in December, 1959, announced plans for the construction of a multi-million-dollar electron tube manufacturing plant at Brookville, Pa. The latter plant is scheduled for completion early in 1961.

Glenshaw Glass Co., Inc.

To construct 150,000 sq. ft. one-story glass container manufacturing plant at Orangeburg, N. Y. Company began manufacturing glass containers in 1895, now operates four melting units in the Pittsburgh district plant at Glenshaw, Pa.

Pittsburgh Plate Glass International

And Algemene Kunstzijde Unie N.V. agreed to enter a study on the establishment of a continuous fiberglass yarn plant in Western Europe. The companies expect the preliminary work to result in a jointly controlled plant to be located near the Western European markets. Plant site will probably be in Holland.

Algemene Kunstzijde Unie N.V. has headquarters in Arnhem, Holland and produces polyester, nylon and rayon fibers. Pittsburgh Plate Glass International, a wholly-owned subsidiary of Pittsburgh Plate Glass Company, began fiberglass production in 1952.

Ball Brothers Co., Inc.

Purchased Atlantic Zinc Works, Inc., and its subsidiary, Rolled Plate Metal Company, Brooklyn, N. Y.

Atlantic Zinc and Rolled Plate Metal produce photoengraving metal for the graphic arts industry. Ball Brothers has glass container plants in Muncie, Ind.; Hillsboro, Ill.; Okmulgee, Okla.; El Monte, Calif.; and Asheville, N. C. It operated rolling mills and metal fabricating plants at Muncie and Greencastle, Ind.; closure plants at Muncie, Chicago, and El Monte, and has three subsidiaries: Kent Plastics Corporation, Evansville, Ind. (decorative plastics); Chardon Rubber Company, Chardon, O., (mechanical rubber goods); and the Ball Brothers Research Corporation, with laboratories at Muncie, and Boulder, Colo.

Atlantic Zinc Works and Rolled Plate Metal Company continue under the presidency of Fred A. Dirkes, director and officer of both companies since 1924.

Libbey-Owens-Ford Glass Co.

Honored 31 employees of company's Charleston, S.C., factory for 25 years of service at 11th annual Service Award dinner, January 6, in Charleston.

Owens-Illinois Glass Co.

Scheduling multi-furnace glass container plant (Brockport, N. Y.) to be completed in 1961. Will occupy approximately 300,000 sq. ft., on 70-acre site. Design will feature latest improvements in glass making.

Company has plants in Bridgeton, N. J.; Alton and Streator, Ill.; Gas City, Ind.; Clarion, Pa.; Charleston, Huntington and Fairmont, W. Va.; Atlanta, Ga.; Waco, Tex.; Los Angeles and Oakland, Calif., and Portland, Ore. Overseas plants include Havana, Cuba; Valencia, Venezuela, and Bogota, Colombia.

Obituaries...

Samuel E. Binswanger

Samuel E. Binswanger, chairman of the board of Binswanger and Company, glass distributing firm, died February 12, at Richmond, Va.

William Hanford Curtiss

William Hanford Curtiss, director and honorary vice president, of Corning Glass Works and president of the Corning Museum of Glass, died January 17, 1960, in Corning, N. Y.

He joined the company in 1920 as assistant to the president, served as vice president from 1929 to 1936 and as vice president and secretary from

William H. Curtiss

1936 to 1953. Mr. Curtiss had also served as trustee of the Corning Glass Works Foundation, vice president and director of the Corning Fibre Box Corporation, director of Corhart Refractories Company and, from 1944 to 1947, was president of Corning Glass Works of South America, a subsidiary.

Frederick C. Sammons

Fredrick C. Sammons, district manager, General Refractories Company, Los Angeles, Calif., died at his home in Los Angeles, January 16.

He joined the company in 1945 when it acquired the Refractories Company of Los Angeles.

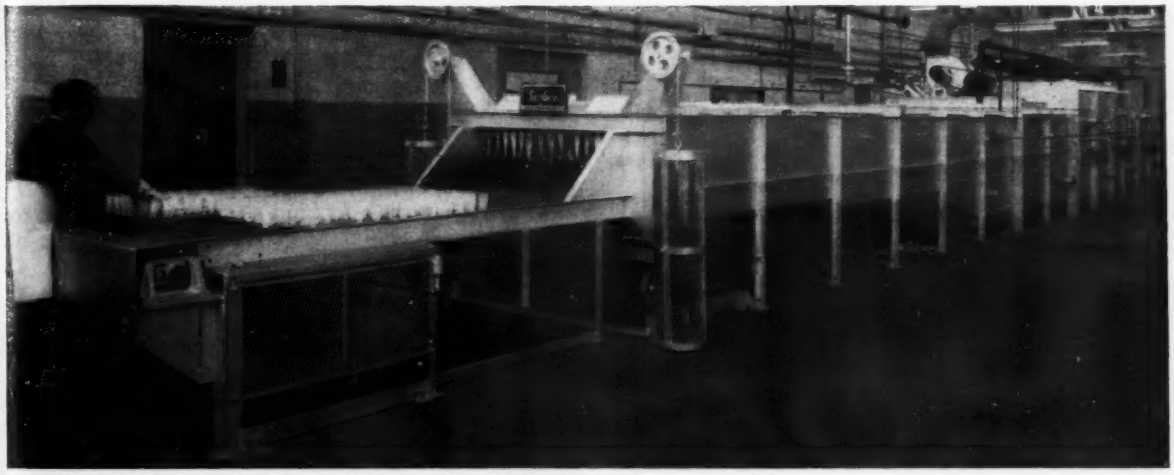
a "useful life" can cost you money

Depreciation policies based on the useful physical life of equipment have lulled many companies into dangerous complacency. By ignoring inflation and technological obsolescence, they pay dividends and taxes on profits which don't really exist.

Inevitably, they discover that their depreciation reserves are inadequate to replace worn out or obsolete equipment.

However, aggressive managements have found two alternatives to that dilemma. First, they prove to the Government that their depreciation rates should be based on the economic—not the physical—life of their equipment.

Second, they purchase equipment which will recoup their investment within its economic lifetime. This is the factor which prompts many companies to specify Surface Combustion lehrs, kilns, and ovens.



This radiant tube decorating lehr is recouping its owner's investment.

Surface Combustion · 2378 Dorr St., Toledo 1, O.
A Division of Midland-Ross Corporation · *In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario*

wherever heat is used in industry

Surface

INVENTIONS AND INVENTORS

Annealing and Tempering

Method of Producing Pattern-Cut Bent Glass Sheets. Patent No. 2,897,632. Filed October 27, 1954. Issued August 4, 1959. No sheets of drawings; none reproduced. Assigned to Libbey-Owens-Ford Glass Company by Ival G. Fowler and Donald W. Dunipace.

The invention relates broadly to an improved method of bending glass sheets or plates. More particularly, it has to do with a novel method of increasing the strength of such articles by controlling the orientation or arrangement of their regional strain patterns, and with bent glass units that have been strengthened in this way.

The method of this invention comprises supporting one or a pair of flat glass blanks or block size sheets that are to be subsequently pattern cut above an outline or peripheral type mold; heating the glass to bending temperature whereupon the sheet or sheets will soften and bend downwardly by gravity to take the contour of the mold; annealing the bent sheet or sheets by gradually reducing the temperature thereof from the bending temperature of the glass to a temperature below which undesirable strains will not be put into the glass by sudden chilling; selectively retarding the cooling of the glass in the annealing range to create, inwardly of the peripheral edges of the sheet or sheets, a regional compression band or area corresponding substantially to the outline of the sheet to be pattern cut therefrom, and then cutting the glass along the compression band in such a way that at least selected portions of the outer peripheral edges of the pattern-cut sheet or sheets will be in compression.

There were 9 claims and 19 references cited in this patent.

Feeding and Forming

Glass pressing nipper rolls. Patent No. 2,895,864. Filed March 23, 1956. Issued July 21, 1959. Assigned to Pittsburgh Plate Glass Company. No sheets of drawings; none reproduced, by Ronald E. Richardson.

This invention relates to improvements in nipper rolls that are employed in the preliminary pressing of laminated safety glass. By far the greatest single use for this safety glass is in the manufacture of windshields and other automobile windows.

The invention consists of the provision in a nipper roll press for the preliminary pressing of curved laminated glass sheets, of a pair of resilient nipper rolls, journal means at each end of each of said rolls, and bearing means for supporting said journal means to maintain the axes of the rolls inclined to each other while lying in a common plane and with the peripheral surfaces of the rolls pressed tightly together along their lengths. In other words, the nipper rolls are in the form of truncated cones, at least in the compressed condition in which they are used in the press. Since they are of rubber or similar resilient material the compressed and relaxed conditions do not necessarily correspond exactly. Nonetheless, however, the rolls are preferably constructed so as also to be truncated cones in the relaxed condition to avoid unequal pressures between the rolls when in the compressed condition.

There were 2 claims and the following references cited in this patent.

United States Patents

1,960,580, Fraser, May 29, 1934; 2,191,144, Hornbostel, Feb. 20, 1940; 2,729,581, Pascoe et al., Jan. 3, 1956; 2,784,585, Kauffman, Mar. 12, 1957.

Furnaces

Vitreous silica and its manufacture. Patent No. 2,897,126. Filed December 2, 1955. Issued July 28, 1959. No sheets of drawings; none reproduced. Assigned to Quartz & Silice S. A., by Henri George.

The invention relates to the manufacture of vitreous silica, embracing a novel process by means of which a greatly improved glass may be produced.

The procedure comprises placing the charge in a graphite crucible and heating it very slowly to the melting point while maintaining the crucible under vacuum. The charge melts after several hours to form an ingot from which pieces of desired shape may be cut. If the process is carefully carried out with pure starting material between 200 and 300 mesh in size, there is produced a glass free from the "orange peel" effect. That effect is due to local variations in the index of refraction greater than 10^{-5}, whereas the new product exhibits no variations greater than 10^{-6}. The desirable result is believed to be due to the very fine particle size of the starting material.

In contrast to the usual method of producing pieces of vitreous silica by melting quartz crystals in a flame it has been found necessary to eliminate flame-melting and to provide as the starting material a charge of fine granules or powder, between 200 and 300 mesh. Pure quartz crystals heated, quenched and ground to between 200 and 300 mesh, are most desirable. It is particularly important to inspect the crystals closely and reject those displaying impurities or included water, since the presence of OH ions in the product results in light absorption

(*Continued on page* 174)

HIGH-TEMPERATURE SYMPOSIUM

(*Continued from page* 139)

densed phase chemistry. Variations with temperature of stabilities and solubilities within a system, are discussed using thermodynamic considerations and illustrated by phase equilibrium diagrams.

The major purpose of the paper was to demonstrate the view of treating all condensed phases as solutions, even those for which variability in composition has never been shown. Thus, a compound such as silicon carbide is viewed not as an isolated chemical system, but as one of an infinity of possible combinations of composition and spatial arrangement in a mixture of the two phase components. The recent consideration of solid semiconductors as ionizing solvents has contributed much to understanding the chemistry and physics of solids, and offers promise in future work.

PYROMETALLURGY

by H. H. Kellogg

COLUMBIA UNIVERSITY

Pyrometallurgy was described as comprising the methods for extraction of metals from ores and of refining metals, which are based on chemical and physical change at high temperature. Some methods of pyrometallurgy, though dating from 3500 B. C., are the basis of the industry today. Understanding the mechanisms involved leads to improvements.

Many significant recent process developments involve a liberal use of oxygen, vacuum, or inert-gas blanketing, and active metal reducing agents such as sodium and magnesium. These were prohibitive in the past because of high cost.

Fluid bed reactors, halide reduction with sodium and magnesium, electrowinning from fused salts, and vacuum retorting of magnesium from dolomite are among the new techniques being utilized. In flash smelting of copper and nickel the powdered sulfides are mixed with oxygen and injected into a combustion chamber; the molten metal and slag fall to the hearth of the furnace, and a rich sulfur dioxide gas is recovered.

Vacuum induction melting and consumable electrode vacuum arc melting are being used commercially for premium quality metal products. The very similar electron bombardment melting produces a better quality product, but the cost is high. Zone and gas-phase refining can produce extremely pure metals. Presently it is limited to production of small-volume, high value products.

HIGH-TEMPERATURE CHEMICAL SYNTHESIS

by Russell C. Phillips and F. Alan Ferguson

STANFORD RESEARCH INSTITUTE

The purpose of this paper was to stimulate consideration of temperatures above 3000°K for chemical synthesis. This temperature limit eliminates all but a few commercial processing techniques, which utilize an electric arc. A discussion of the processes and tools which could be utilized was given and some products of interest were noted.

Some of the foreseen problems in operating above this range, and some possible solutions are:

1. Materials of construction are unavailable; conventional reactors must be replaced by imaginative designs.
2. All other sources of thermal energy are too expensive compared with fossil fuels, which are not satisfactory. Arc efficiencies must improve and the power cost gap narrowed.
3. Chemical compositions cannot be frozen from high temperature equilibrium. New cooling principles must be developed.
4. Fundamental high-temperature data are meager.
5. There seems to be no financial incentive for this type of research. The extent to which existing processes will be replaced is difficult to predict, but the possibilities are intriguing.

MECHANICAL PROPERTY BEHAVIOR OF METALS AT ELEVATED TEMPERATURES

by Nicholas J. Grant

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The high-temperature properties of metals, the effect of various parameters on high-temperature strength, and the methods for improving the properties were discussed.

The importance of strain and ductility on fracture was noted, and a problem on the judgment of the value of ductility was presented.

In high-temperature testing the method of heating together with its effect on the measured properties, and the effect of the atmosphere, are the two major problems. The areas where much more extensive studies are required were described, and observed effects of the testing atmosphere on metals were given.

The following factors which contribute to the high-temperature mechanical properties of a metal were given, and methods for their control were discussed:

1. Melting temperature and recrystallization temperature
2. Crystal structure
3. Alloying effects
4. Two and multi-phase strengthening—aging and non-aging
5. Hot and cold working effects
6. Grain size
7. Dispersion hardening.

FUSED SALT CHEMISTRY

by George J. Janz

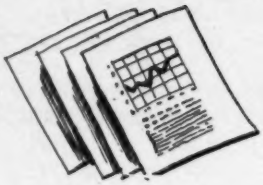
RENSSELAER POLYTECHNIC INSTITUTE

Some aspects of the structure of molten salts of current interest to both theoretical and experimental research workers. Models for molten salts based on liquid state theories and on electrochemical properties of these systems were considered. Experimental methods, potential information, and current problems were surveyed.

From the theoretical side, molten salts form a special class of liquids in which oppositely charged ions, simple or complex, are in intimate contact.

From the practical side, they are among the largest class of non-aqueous inorganic solvents, and, as such, form systems which are liquid up to 3000°C, with conductivities ranging from zero to 500 times greater than

(*Continued on page* 176)



RESEARCH DIGEST

Devitrification of High-SiO_2 Glasses of the System Al_2O_3—SiO_2

● NORMALLY, IF A GLASS is heated to temperatures between its transformation range and the liquidus temperature, a process known as devitrification will occur, i.e., crystalline nuclei will form and grow, eventually transforming part or all of the amorphous phase into one or more crystalline phases. But there are some glassforming substances (e.g., polystyrene and polymethyl methacrylate), possessing certain stereochemical irregularities, which have never been crystallized. Devitrification normally is regarded as an adversary of the glass manufacturer or the glass blower. The so-called "stones" which result from devitrification not only ruin the appearance and optical properties of glass but make it unfit for structural applications as well. Although the formation of highly vitreous porcelains may involve separation of crystalline phases, the one instance in which devitrification has been extensively applied advantageously is in the manufacturer of Pyroceram (the Corning Glass Works family of " . . . extremely hard, fine-grained crystalline materials . . ." which is formed from special glass compositions by controlled devitrification). Thus there is ample motivation for research into the factors governing the devitrification process.

The present study by S. D. Brown and S. S. Kistler (*Journal of the American Ceramic Society*, June, 1959) developed from the hypothesis that growth of crystals from a high-silica glass matrix occurs through the addition to the growing surfaces of network fragments larger than SiO_3^{2-} ions, probably six-membered siloxane rings, and that structural irregularities of these network fragments, arising through the replacement in a fragment of a silicon ion by one of different size, such as Al^{3+} or Zr^{4+}, would make crystallization much more difficult than in pure SiO_2 glass. This hypothesis has considerable substantiation in organic glasses. For example, in cellulose triacetate, crystallization ocurs with great ease, but replacement of one of the acetate groups with hydroxyl reduces the tendency to crystallize by a large factor. The same phenomenon is observed with vinyl chloride. This polymer is always crystalline, but an occasional replacement of a chlorine by an acetate or butyrate group tremendously suppresses the tendency to crystallize.

The purpose of this paper was to report experimental data and methods which resulted from a study of the devitrification of high-silica glasses of the system Al_2O_3–SiO_2. High-purity silica glasses were selected for study rather than low-temperature conventional glasses (e.g., soda-lime-silica glass or Pyrex-brand glass) because it was believed that data on the composition dependency of the devitrification rate would be more easily understood and more likely to result in useful general relations in the case of the high-silica glasses than in the case of the low-temperature glasses, which have comparatively complex compositions and may devitrify to several crystalline phases. Furthermore, the separation of a crystalline phase from a glass of complex composition often impoverishes the surrounding glass of the ions involved in crystal formation, and the rate of crystallization becomes dependent on the rate of transport of crystal-forming material from the glass bulk through the impoverished region to the glass-crystal boundary. The retarding influence of a zone of inert, non-crystal-forming material between the glass bulk and the crystal surface is largely eliminated in nearly pure silica glasses.

In the present study small amounts of Al_2O_3 were added to an ultra-pure type of silica called Cab-O-Sil-"O". The temperature functions of the devitrification rates and the viscosities of the Al_2O_3-bearing glasses were compared with those of pure Cab-O-Sil-"O" glass and a spectroscopically pure fused silica manufactured by the Corning Glass Works. It was found that the Al_2O_3-bearing glasses devitrified more rapidly to cristobalite than either the Cab-O-Sil-"O" glass or the Corning fused silica.

Superficially, the data for the system Al_2O_3-SiO_2 of the present investigation would appear to agree with the results published by Tabata, Yegami, and Toda and to disagree with those reported by Mullensiefen and Zschimmer, Horak and Sharp, Swift, and Kainarskii and Degtyareva. But from a structural standpoint, the system dealt with in the present study and those of the previous investigators (the systems studied by Kainarskii and Degtyareva being possible exceptions) are vastly different.

On the basis of data reported in this paper, the follow-

(*Continued on page* 174)

SOLVAY
POTASSIUM CARBONATE
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CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during December, 1959, was as follows: *Flat Glass*: a preliminary figure of 32,200 for December, 1959, indicates an increase of 0.3 per cent over the adjusted figure of 32,100 reported for November, 1959. *Glass and Glassware, Pressed and Blown*: a decrease of 1.0 per cent is shown by the preliminary figure of 86,300 reported for December, 1959, when compared with the adjusted figure of 87,200 reported for November, 1959. *Glass Products Made of Purchased Glass*: the preliminary figure of 14,700 given for December, 1959, is 3.9 per cent under the adjusted figure of 15,300 reported for November, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	January, 1960
Food	1,108,000
Medicinal and Health Supplies	1,433,000
Chemical, Household and Industrial	938,000
Toiletries and Cosmetics	735,000
Beverage, Returnable	539,000
Beverage, Non-returnable	93,000
Beer, Returnable	126,000
Beer, Non-returnable	712,000
Liquor	584,000
Wine	381,000
Sub-total (Narrow)	6,649,000

Wide Mouth Containers

Food	*3,304,000
Medicinal and Health Supplies	396,000
Chemical, Household and Industrial	126,000
Toiletries and Cosmetics	284,000
Dairy Products	141,000
Sub-total (Wide)	*4,251,000
Total Domestic	10,900,000
Export Shipments	208,000
TOTAL SHIPMENTS	*11,108,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production December 1959	Stocks December 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,686,000	6,758,000
	Wide Mouth	*4,785,000	*6,078,000
Beverage, Returnable		858,000	1,943,000
Beverage, Non-returnable		118,000	277,000
Beer, Returnable		195,000	439,000
Beer, Non-returnable		824,000	900,000
Liquor		728,000	1,605,000
Wine		475,000	790,000
Dairy Products		199,000	333,000
TOTAL		*12,669,000	*19,123,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

Payrolls in the glass industry during December, 1959, were as follows: *Flat Glass*: a decrease of 1.0 per cent is shown in the preliminary $17,560,314.44 given for December, 1959, when compared with November's $17,745,012.89. *Glass and Glassware, Pressed and Blown*: a decrease of 0.5 per cent is shown in the preliminary $33,317,866.89 reported for December, 1959, when compared with the previous month's adjusted $33,495,303.24. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,764,393.48 was reported for December, 1959. This is a decrease of 3.1 per cent when compared with the adjusted figure of $4,919,744.53 for November, 1959.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 12,669,000 gross during January, 1960. This is an increase of 12 per cent over the previous month's production figure of 11,257,000 gross. During January, 1959, glass container production was 11,453,000 gross, or 9.5 per cent less than the January, 1960, figure.

Glass Container Shipments during January, 1960 came to 11,108,000 gross, an increase of 4.6 per cent over December, 1959. Shipments during January, 1959, amounted to 11,192,000 gross or 7.5 per cent less than January, 1960.

Stocks on hand at the end of January, 1960 came to 19,123,000 gross. This is 0.8 per cent more than the 18,953,000 gross on hand at the end of December, 1959, and 1.8 per cent more than the 18,771,000 gross on hand at the end of January, 1959.

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NEW EQUIPMENT AND SUPPLIES

Glass Inductors

Corning Glass Works, Corning, N. Y., has developed a kit of glass inductors to be used in new electronic circuits requiring high stability.

Kit includes 10 inductors; four tuning cores to regulate inductor values, and a 50-page technical brochure.

Compressed Air Dryer

General-Erie, Erie, Pa., has available a two-stage (non-regenerative) general air dryer for compressed air systems. Combines both mechanical and chemical methods for removal of all water and moisture vapors and is said to provide a dewpoint as low as minus 20°F. First stage utilizes a helical centrifugal chamber as a pre-filter for the air stream. Water and other particle contaminants are removed leaving the vapor content to enter the desiccant bed.

Dryers are available in 12 standard models, ranging up to 2250 CFFM capacities. Standard working pressures are 150 and 200 psi.

Glass Cutting

Export Dept., Fletcher-Terry Co., New York City, has available bronze cutting units for glass cutting production equipment. Devices are complete with wheel, axle and sidewall. Replacements are accomplished by sliding out the old unit and inserting the new one.

Battery Charger

Exide Industrial Division of The Electric Storage Battery Co., has a shelf bracket mount for silicon-rectifier battery chargers. The brackets can hold Exide model batteries: PMR-6-360, PMR-6-450, and PMR-6-660.

Air Compressors

Atlas Copco, New York, N. Y. is marketing a series of low pressure air compressors delivering from 372 to 1430 cubic feet of air per minute at pressures ranging up to 45 psi.

Three sizes are available. They are water-cooled, double acting, single-stage units featuring two cylinders of equal size. Compressors are equipped with pulsation dampers in place of standard-type intercoolers.

Tank Drains

Wilkerson Corp., Englewood, Colo., is producing float operated tank and sump drains designed to collect and automatically discharge large volumes of moisture and sludge from compressed air systems. Unit is said to automatically drain contamination as long as 10 psi air pressure or more remains in the air system. Maximum operating pressure on both units is 250 psi. They are available in pipe sizes of ½ in. and 1 in.

Laboratory Glassware

Fischer & Porter Co., Hatboro, Pa., has been appointed a distributor of the full line of laboratory glassware manufactured by Kimble Glass Co., Toledo, O.

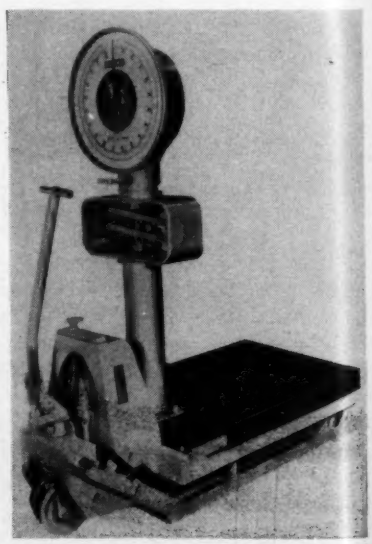
Walkie-Rider

Lewis-Shepard, Products, Inc., Watertown, Mass., is producing a walkie-rider, carry-all truck for use as a baggage truck, interplant delivery truck or an order selector truck.

Machine has 12 or 14 volt electric systems and is available in capacities ranging from 2000 pounds to 10,000 pounds. Equipped with removable shelving.

Portable Scale Truck

Lewis-Shepard, Watertown, Mass., has a portable scale truck which incorporates a scale as an integral part of the hydraulic footlift truck. It is said to enable commodities to be moved and weighed simultaneously. Built with special lifting angles to hold the scale, each truck must be adapted to suit the design and capacity of the scale to be used.



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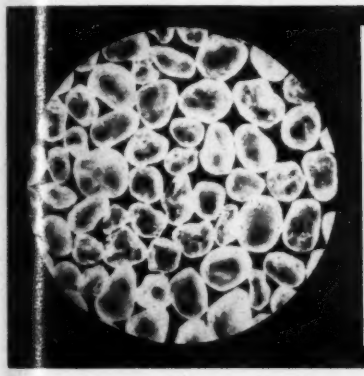

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Shatterproof Windshield Containers

Shatterproof Glass Corp., Detroit, Mich., is manufacturing a triangular container with slotted top and bottom supports for shipping laminated safety glass windshields.

Two triangular supports at both top and bottom are fastened to 2 x 4's. Top supports are aligned with bottom supports and held by steel strapping. A shoulder on the triangular bottom support is designed for sufficient play to eliminate inflexibility and subsequent damage.

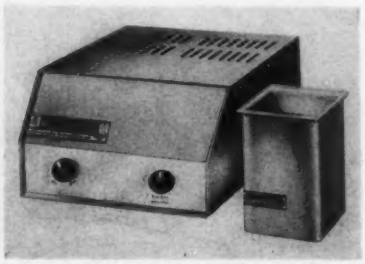
Lead Carbonate

South American Minerals & Merchandise Corp., New York City, is offering a low iron content basic lead carbonate for glass and ceramic applications. The lead carbonate is a component of glazes, used in the manufacture of whiteware, earthenware, enamel and vitreous tile.

Ultrasonic Cleaner

Ultrasonic Industries, Inc., Albertson, L.I., N.Y., has an ultrasonic cleaner said to disintegrate quickly more than fifty distinct classes of soils and contaminants in products ranging from surgical instruments, watches, clocks, to highly complex electronic components used in satellites and missiles.

Unit includes a 40 watt generator with 90,000 cycles per second output and a half-gallon capacity. Tank is heavy gauge stainless steel deep drawn with rounded corners. It is finished with 4A grade high polish to avoid soil entrapment in crevices or corners.



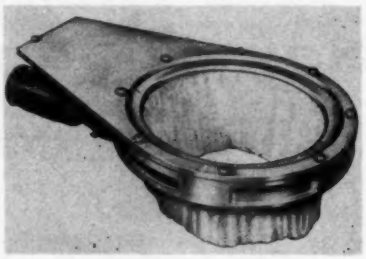
Weight Calibration Checker

Toledo Scale Corp., Toledo, O., is offering a calibration checker designed to provide a convenient and time-saving method for checking the calibration of Toledo Electronic Load Cell Scales. Instrument is said to allow the scale operator to quickly and easily verify the indicating accuracy of a load cell scale without the use of test weights.

Incorporated into all new Toledo Electronic Load Cell Scales during manufacture, the device is set and locked on a voltage equal to full dial capacity during initial installation test.

Flow Control Valve

Syntron Co., Homer City, Pa., is manufacturing motorized flow control valves for positive control of flow and shut-off of bulk materials from bins, hoppers, and chutes. Valves can be



placed in inaccessible locations where manual operation is not possible. Operation of one or more valves can be controlled from a central location, eliminating the necessity of individual manual operation. A flexible diaphragm forms a concentric aperture which may be varied to form numerous openings by energizing the motor. Diaphragm presents a resilient surface which rolls the material with it in closing and eliminates lodging and jamming of material in aperture. Diaphragm also prevents opening and closing at a control point in a process.

Industrial Microscope

Edmund Scientific Co., Barrington, N. J., is offering a low-power microscope with a direct reading scale reticle. It can be used for the inspection of sand, ores, textiles and machined surfaces and castings.

Reticle has .4 in. long scale with .005 in. gradations for 10 power use; scale is .2 in. long with .0025 in. gradations for 20 power use. Microscope is 6 in. long with 4½ in. x 4½ in. base. It can be raised from 8½ in. to 13 in.

CATALOGS RECEIVED

Pressure controller. (2 pages) Describes pneumatic controller for pressures to 170 psig and for differentials from –30 in. H_2O to +30 in. H_2O. Includes complete tabulation of piping recommendations and schematic drawing showing operation.

BAILEY METER CO., Cleveland, O.

Hand chain hoists. (8 pages) Contains tables and recommended minimum standards on differential, worm-geared and spur-geared types of hand chain hoists; hook or lug suspension and plain or geared trolley.

HOIST MFG. ASSOC., Washington, D. C.

Thermocouple insulators. (5 pages) Bulletin describing the uses and technical specifications of fused magnesium oxide, aluminum oxide, and zirconia thermocouple tubing used in connection with aircraft turbines, atomic reactors.

NORTON CO., Worcester, Mass.

Air-Hydraulic boosters. (24 pages) Describes conversion of shop air into intensified (up to 10,000 psi and over) hydraulic pressures for operating hydraulic cylinders by air-hydraulic boosters. Contains price, mounting and dimensional data on different models.

FLICK-REEDY CORP., Bensenville, Ill.

Haulage Machines. (20 pages) Illustrated. Booklet contains 14 typical layouts of the applications to which car spotters and car pullers can be adapted. Tables, engineering and selection data are given and 33 accessories are described.

LINK-BELT CO., Chicago, Ill.

Materials handling equipment. (16 pages) Specifications and illustrations on fork lift trucks, tractors, narrow aisle electrics, electric powered walkies and manual equipment. Equipment selector chart as a visual reference for all equipment manufactured in each line of materials handling equipment.

LEWIS SHEPARD PRODUCTS, INC. Watertown, Mass.

Air vibrator applications. (4 pages) Bulletin gives specifications, mounting information and detailed applications on bins, chutes and hoppers for eight different Navco vibrator models. Illustrated.

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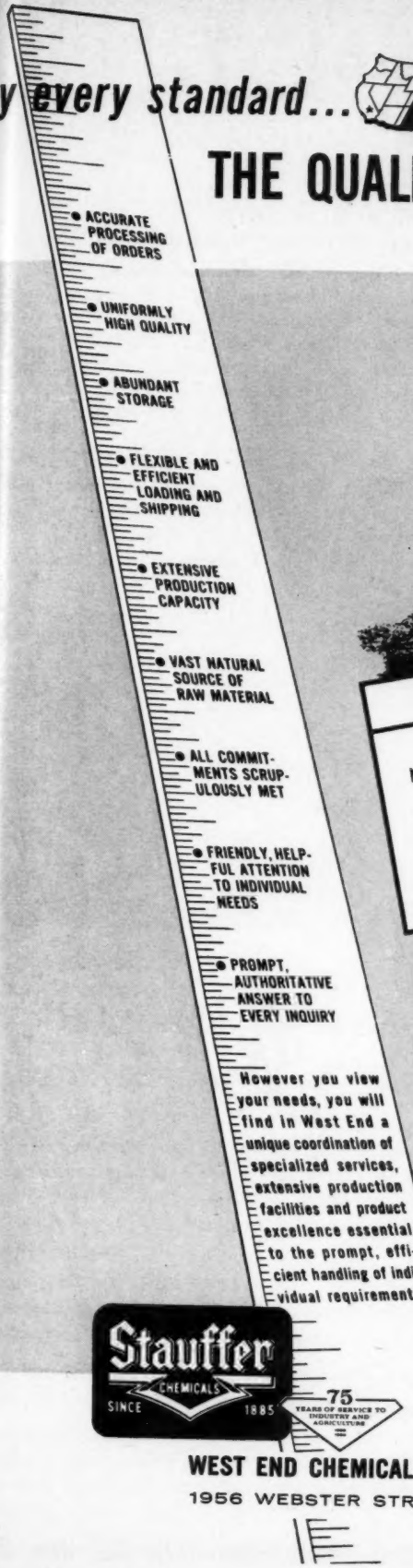
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NEW BOOKS

THE NIMONIC ALLOYS, *by W. Betteridge, D. SC. F. Inst. P.* Published by Edward Arnold Limited, 319 pages, 144 references with author and subject indexes.

As a leader of a research team working for the past twelve years in the laboratories of the Mond Nickel Company, Doctor Betteridge was in large part responsible for many of the recent advances in knowledge of the Nimonic family of nickel-base precipitation-hardening alloys.

This is a practical book of the sort that can be put to use at once by users and prospective users of the higher alloys.

With the exception of melting data on the alloys the book is complete. A short note on creep in metals leads into the chapter of the Ni, Cr, Co, Al, Ti alloy system then through the metallography to mechanical and physical properties, welding, machining and uses.

This book will be useful to students of metallurgy, mechanical engineering, design engineers and material selection officers as well as to that rapidly enlarging field in commerce and industry where the NIMONICS are being employed.

RESEARCH HIGHLIGHTS
OF THE NATIONAL BUREAU OF STANDARDS

Annual Report 1959. National Bureau of Standards, Miscellaneous Publication 229, 169 pages. 55 cents. Order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Describes most important developments in the research program of the National Bureau of Standards during the past year. This report contains:

a. Summary of the Bureau's Calibration, Testing and Standard Samples programs.
b. Publications program.
c. Cooperative research with industry.
d. Brief listing of programs scheduled for 1960.

The new technology of the space age is represented in length including special measurements of the heat conductivity of explosives and solid propellants. Also covered are the confirmation of the Rydberg constant,

(*Continued on page* 181)

TEN YEARS OF PROGRESS IN THE GLASS INDUSTRY

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This comprehensive report was originally published in THE GLASS INDUSTRY in two installments (November and December, 1959).
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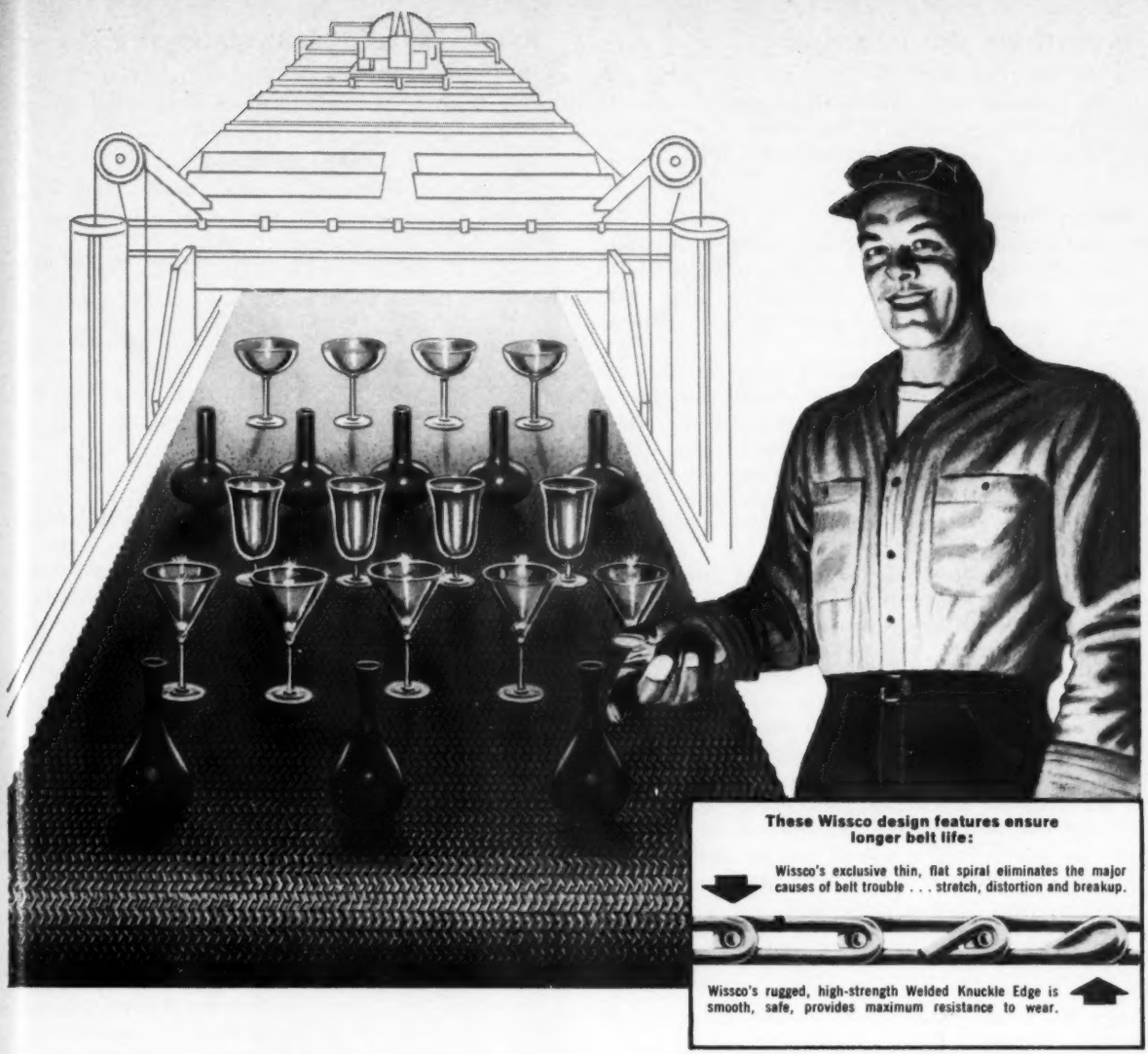
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6877

INVENTIONS AND INVENTORS

(*Continued from page* 162)

in the infra-red range. Moreover products of reduction or carburetion are strictly to be avoided.

There were 4 claims and 10 references cited.

Glass Compositions

Method of and Furnace for Melting and Refining Glass. Patent No. 2,899,476. Filed November 6, 1956. Issued August 11, 1959. No sheets of drawings; none reproduced. Assigned to Elemelt Limited by Philip Anthony Maunsell Gell.

The present invention consists of furnaces for melting or refining glass of the kind wherein the glass is heated by the passage of alternating electric current therethrough, such furnaces comprising a furnace chamber and a further chamber which is connected with the furnace chamber by a duct through which the molten glass and an auxiliary alternating electric current can be caused to flow.

The furnace chamber may be a melting chamber into which the batch materials in solid form are fed and melted, in which case the further chamber is either a refining chamber (no refining or only partial refining taking place in the melting chamber). Alternatively the furnace chamber may be both a melting chamber and a refining chamber, the further chamber then being a storage chamber such as a forehearth from which the glass refined in the furnace chamber is fed out directly or indirectly for fabrication. Alternatively the furnace chamber may be a refining chamber (which has been preceded by a melting chamber), and the further chamber may be either a further refining chamber or a storage chamber such as a forehearth.

There were 19 claims and 11 references cited in this patent.

Glass Wool and Fiber

Treatment of fibrous glass with aqueous emulsions of metals and alloys. Patent No. 2,886,470. Filed December 28, 1953. Issued May 12, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Corning Fiberglas Corporation, by John K. Park and Alfred Marzocchi.

This invention relates to treatments for fibrous material and particularly to methods of applying metals and alloys of metals to fibrous glass to enhance its properties.

Any metal or alloy of metal which is liquid at temperatures below the boiling point of water may be emulsified with water and applied to the glass surface and then dried to form a coating of metal. Wood's alloy comprising 50 per cent bismuth, 25 per cent lead, 12.5 per cent tin and 12.5 per cent cadmium which melts at about 71° C. is introduced into water which is then heated to a temperature above the melting point of the metal. The mixture is violently stirred in homogenizing equipment to provide a finely divided emulsion of molten metal and water. Fibrous glass is then introduced into the emulsion to substantially coat the surface of the glass. The water is removed by drying to provide a coating of the 50:25:-12.5:12.5, bismuth-lead-tin-cadmium alloy on the glass surface.

There were 4 claims and 10 references cited.

RARE EARTHS IN GLASS INDUSTRY

(*Continued from page* 153)

to a group of new refractory oxides that the glass industry should find most worthwhile.

BIBLIOGRAPHY

1. Wisnyi, L. G., and Pijanowski, S., *Metallurgy Report of the Tech. Dept., KAPL-1564* (1956).
2. Ploetz, G. L., Krystyniak, C. W., and Dumas, H. E. *J. Am. Ceram. Soc., 41*, 551-54 (1958)
3. Curtis, C. E., *J. Am. Ceram. Soc., 40*, 274-8 (1957).
4. Curtis, C. E., and Johnson, J. R., *J. Am. Ceram. Soc., 40*, 15-19 (1957).
5. Brewer, L., *Publication of the U.S. Atomic Energy Comm., UCRL-1931* (Sept. 1952).
6. Stair, R., and Faick, C. A., *J. Res. Natl. Bureau Standards, 38*, 95-101 (1947).
7. Kreidl, N. J., *J. Am. Ceram. Soc., 25*, 141-3 (1941).
8. Weidert, F, and Loffler, H., U. S. Patent 2,219,122, Oct. 22, 1940.
9. Schaefer, C., and Rosemann, J., *Z. tech. Physik., 20*, (7), 193-98 (1939).
10. Bouma, F. J., *Philips Tech. Rev., 3*, (2), 27-29 (1938).
11. Long, B., Brit. Patent 450,513, July 15, 1936.
12. Brewster, G. F., Kreidl, N. J., and Pett, T. G., *Trans. Soc. Glass Tech., 31*, 153-69 (1947).
13. Geffcken, W., U. S. Patent 2,745,757, May 15, 1956.
14. Ploetz, G. L., and Ray, W. E., U. S. Patent 2,859,163, Nov. 4, 1958; also, *KAPL-1617*, Nov. 27, 1956.

Acknowledgment

Acknowledgment is made to Dr. Howard E. Kremers and S. B. Treat of Lindsay Chemical Division, American Potash & Chemical Corp., for their cordial cooperation in providing data used in this series of three articles.

RESEARCH DIGEST

(*Continued from page* 164)

ing conclusions were drawn concerning the devitrification of the high-silica glasses of the system Al_2O_3-SiO_2 studied in this investigation.

(1) The growth of a cristobalite zone from a uniformly nucleated air-glass surface toward the interior of a glass body follows a zero-order rate law. One would expect a departure from the zero-order law toward the end of the devitrification reaction, particularly if an appreciable amount of non-crystal-forming impurity had accumulated in the path of the advancing cristobalite front. The writers were unable to detect any definite departure from the zero-order rate law, however, even in cases where less than 8×10^{-2} sq. mm. of a specimen cross section (total area $\backsim$ 1.2 sq. mm.) remained noncrystalline.

(2) The temperature dependence of the growth rate over the temperature range 1288° to 1457°C. is given by $\ln (g/T) = -(B/T) + \ln A$, where A and B are constants which are functions of Al_2O_3 content, T is the absolute temperature, and g is the growth rate.

(3) The isotherms of both viscosity and devitrification growth rate pass through maxima near $(Al^{3+}/Si^{4+}) \times 10^2 = 0.225$. Indeed, the growth rates for all specimens with added Al_2O_3 are greater than the growth rates for fused Cab-O-Sil-"O" or Corning fused silica, whereas the corresponding fluidities (i.e., reciprocal viscosities) are equal or, most usually, less. Inasmuch as the same crystalline phase (cristobalite) separated in all cases, and inasmuch as the liquidus temperatures of the Al_2O_3-containing glasses are less than those of the fused Cab-O-Sil-"O" or the Corning fused silica, one might expect results just the opposite from those here presented. That is, on the basis of the viscosity data alone one might anticipate a decrease in the growth rate with increasing alumina content rather than the increase reported in this paper.

(*Continued on page* 183)

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HIGH-TEMPERATURE SYMPOSIUM

(*Continued from page* 163)

aqueous electrolytes, and with viscosities from 0.1 cp to 10^5 poise. Fused salt technology is currently being employed in metallurgy and in nuclear energy. Investigations are underway for employing fused salts in fuel cells and thermoelectric generators.

THERMOELECTRIC POWER

by Clinton M. Kelley

STANFORD RESEARCH INSTITUTE

A general review of the present knowledge of thermoelectric generation of power, including materials, power generators, thermodynamics, and thermionic power convertors. The principles involved are those developed by Seebeck, Peltier, and Thompson over a century ago. Generator efficiences were discussed, and the figure of merit, which is used to screen or evaluate materials is given as the Seebeck coefficient divided by the product of the thermal conductivity and the electrical resistivity.

Compound semiconductors have been found to be the most promising thermoelectric materials so far. Some examples are bismuth telluride, (Bi_2Te_3), bismuth selinide, (Bi_2Se_3), or alloys of the two. Alloying or doping of materials is being investigated in the hope of finding more efficient materials, but prediction of properties is limited by present theory.

Liquid semiconductors are being investigated and their outlook is good. There is some difficulty in measuring thermal conductivity, however, and precise determinations of the figure of merit have not been possible.

Thermionic power convertors are closely related to thermoelectric generators, and work on the principle of thermionic emission where a current is developed between a hot cathode and a cold anode in a device similar to a vacuum tube. High efficiencies are expected with future materials development.

MASS SPECTROSCOPY APPLIED TO HIGH-TEMPERATURE CHEMISTRY

by M. G. Inghram and J. Drowart

UNIVERSITY OF CHICAGO

Identification and study of gaseous species at high temperatures are being done with the mass spectrometer. Complex molecular equilibrium with a solid at high temperatures, such as SiC_2 and Si_2C over SiC, B_2O_2 and B_2O_3 over B and B_2O_3, and Be_3O_3 over BeO, which were heretofore unexpected, are being characterized. The identification of such molecules has given entirely new aspects to the usual concepts of chemical bonding and valency, and consequently, the field of gas chemistry at high temperatures is rapidly broadening.

As a result of the success which the mass spectrometer has had in high temperature studies, this summary was presented to show what the technique is, what it can do, and what its shortcomings are. To illustrate the importance of the method, a listing of the vaporization results obtained to date were given. A section was also included to suggest a number of additional applications of mass spectroscopy to high-temperature chemistry, and all work was meticulously referenced.

HIGH-TEMPERATURE RESEARCH IN THE UNITED KINGDOM

by J. White

UNIVERSITY OF SHEFFIELD

In the past few years there has been a marked increase in the volume of research carried out in the United Kingdom on high-temperature materials and processes. This is evidenced by the increasing number of conferences and symposia being held, and by the formation of a Powder Metallurgy Group and publication of the journal "Powder Metallurgy."

Much work on the mechanism of sintering is being carried out. The effect of grain boundaries, pores, purity, stoichiometry, and time on the process of sintering is being studied. An extensive series of investigations has been carried out on the sintering of the so-called "active" form of MgO and BeO, prepared by low-temperature calcination of the hydroxides. These active forms have higher heat capacities and heats of solution than oxides formed at higher temperatures. Also they sinter at lower temperatures; some discussion has taken place as to whether this is the result of internal strain or distortion due to the low temperature formation, or to the extremely fine crystal size and, consequently, large surface area. A method of zone sintering similar to zone refining, was described, capable of producing high density, impermeable ware to close tolerances without cracking.

In the field of non-oxide ceramics, work was reported on the study of bonding, structure, and the physical properties of the carbides, borides, nitrides, and silicides. Self-bonded silicon carbide was prepared by heating a pressed mixture of SiC and colloidal graphite in silicon vapor. Densities of 3.0 gm/cc and room temperature rupture strengths of 30,000 psi were obtained.

An increase in the thermal shock resistance of Cr-Al_2O_3 cermets was gained by adding small amounts of molybdenum to the body which caused a more close matching of the thermal expansions of the metal and the oxide phases. Nuclear fuel elements were made of a Fe-UO_2 cermet which offered the advantages of high thermal conductivity and thermal shock resistance, and of localization of fission product damage.

In a study of chrome-magnesite refractories, it was found that the high-temperature weakening of these refractories is caused by the formation of silicate phases (foresterite and monticellite) made possible by the silica and lime impurities found in chrome ores.

RECENT FRENCH CONTRIBUTIONS TO HIGH-TEMPERATURE RESEARCH

by F. Trombe and M. Foex

SOLAR ENERGY LABORATORY AT MONT LOUIS, FRANCE

The high temperature research conducted in France from 1954 to 1959. Both published and unpublished work was reported, and all pertinent references were indicated.

Work on production of high temperatures included resistance furnaces (both metallic and carbon tube), induction furnaces, arc furnaces, electron bombardment, arc-image furnaces, solar furnaces, electronic torches, and high temperature plasmas.

Various means of temperature measurement were studied including photographic and optical techniques,

Soon To Be Published Vol. II. HANDBOOK OF GLASS MANUFACTURE

Volume I of the Handbook of Glass Manufacture was originally published in 1953 by the Ogden Publishing Company. Uninterrupted demand for the book necessitated a second printing in 1957 in order to meet the needs of all those concerned with glass manufacture, technology and engineering. Both the first and second printing of Volume I have been sold out.

As a supplement to the first edition, Volume II of the Handbook of Glass Manufacture will be published on or about April 15, 1960, and will again be edited by Dr. Fay V. Tooley, Professor of Glass Technology, Department of Ceramic Engineering, University of Illinois.

CONTENTS . . .

Chemical and Instrumental Analysis of Glass
Francis Glaze, Consultant
John Time, Owens-Corning Fiberglas Corp.

Optical Properties of Glass: Effects of Radiation on Glass
Norbert J. Kreidl, Bausch and Lomb Optical Co.

Scientific Glass Blowing
Vincent DeMaria, Glass Products Development Laboratory

Flat Glass Manufacturing Processes
Roy G. Ehman, Pennsylvania State University

The Quality Control Chart
Ronald Wiley, Owens-Corning Fiberglas Corp.

Electric Melting of Glass
Larry Penberthy, Penberthy Instrument Co.

Constitution and Structure of Glass
Fay V. Tooley, University of Illinois

The Glass Industry
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such as photoelectric and two-color pyrometers. The measurement of temperatures, emissivities, and fluxes of the solar and arc-image furnaces were also reported.

Physical measurements at high temperatures were made using thermo-balance, dilatometric, and X-ray crystallographic techniques. The secondary transformations of silica were studied by an enthalpic method similar to differential thermal analysis. The high-temperature creep of glass was reported along with work on other mechanical properties.

Results of work on the preparation, purification, and sintering of metals was reported, as well as much work on the oxides, borides, sulfides, nitrides, carbides, intermetallic compounds, and molten salts.

A discussion of the work on the properties of gases at high temperatures and gas phase reactions indicated the extensiveness of current French research.

HIGH-TEMPERATURE RESEARCH ACTIVITY IN GERMANY

by Walter Lochte-Holtgreven
KIEL UNIVERSITY, GERMANY

Primarily concerned with research relative to the electric arc, the shock tube, and various kinds of electric discharges.

The use of a carbon arc apparatus to crack heavy hydrocarbons was described, as well as a process for separating elements and isotopes by thermal diffusion in a high voltage arc in a long thin tube.

The shock tube was used to investigate the combustion and detonation of hydrocarbons. The densities of shock waves in a gas were studied with short-duration X-ray flashes.

Progress in the analysis of free radicals was furthered by the use of discharge tubes in the study of the decomposition of organic molecules. Mass analysis of heavy negative ions is being done, and extremely good resolution has been achieved.

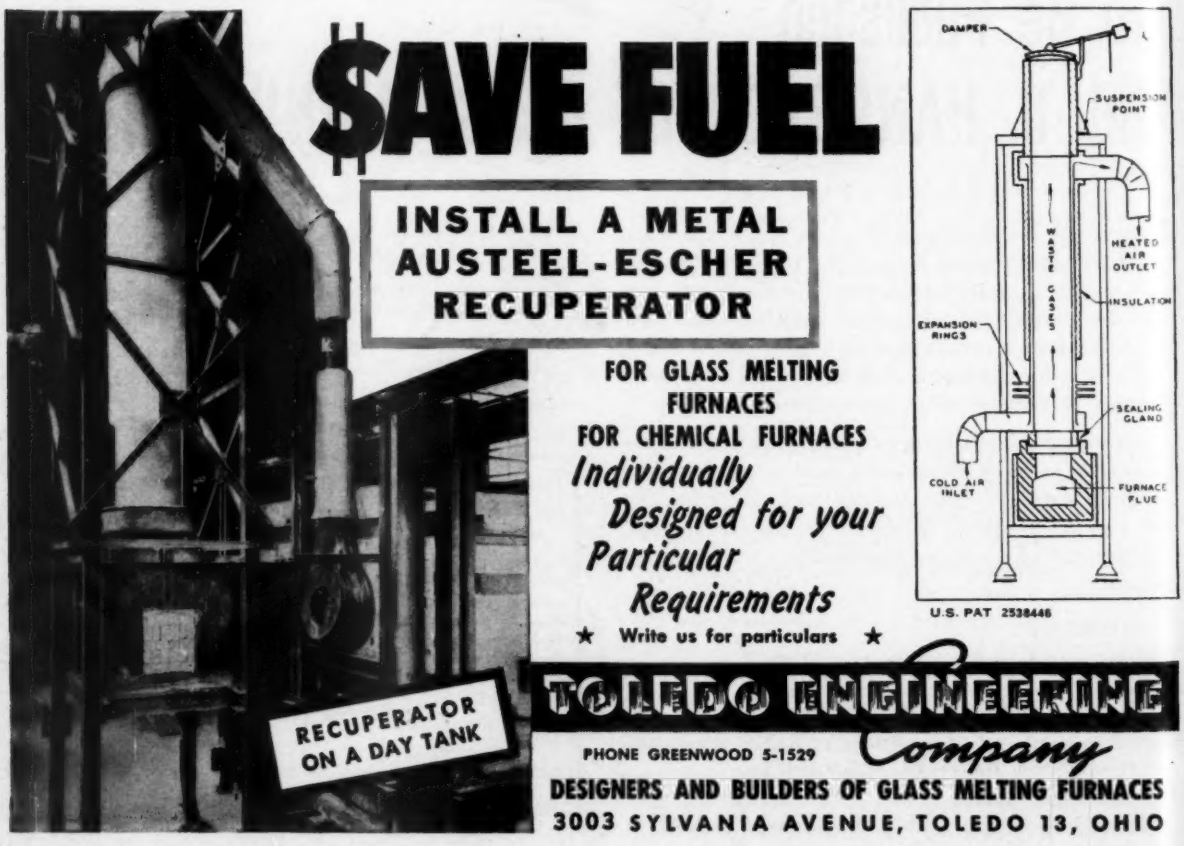
HIGH-TEMPERATURE RESEARCH IN JAPAN

by Hisao Mii
GOVERNMENT INDUSTRIAL RESEARCH INSTITUTE
NAGOYA, JAPAN

The major part of this review concerned solar furnace research in Japan. Other work described included the melting of carbon, the crystallinity of molten carbon, studies of silicon carbide, and ceramic nuclear fuel elements.

Two solar furnaces are now operating in Japan. One is capable of melting Cr_2O_3 (M. P. ~ 2275°C); and the other can melt thorium oxide (M. P. > 3000°C). A series of experiments on the fusions of metal oxides has been carried out, and the reactions were described with a series of photomicrographs. Work is now in progress on the manufacture of acetylene by pyrolysis of gaseous hydrocarbons.

Carbon was melted in a specially designed apparatus operating at 100 atmospheres and 4000°K, and a carbon sphere was formed which was flexible and easily de-



formed. It consisted of thin plates of well-developed graphite single crystals.

Silicon carbide was studied with the intention of improving the efficiency of the manufacturing process. The electrical properties were also studied, particularly how they could be controlled in the manufacturing process.

Specimens in the system UO_2-ThO_2 were prepared to 97 per cent theoretical density by sintering a calcined mixture of coprecipitated uranyl nitrite and thorium nitrate, in an air – CO atmosphere at 1400°C.

HIGH-TEMPERATURE RESEARCH IN SCANDINAVIA

by H. Flood

NORWEGIAN INSTITUTE OF TECHNOLOGY

Some general and historical points were given concerning the four Scandinavian countries, Denmark, Finland, Norway, and Sweden. The industries, natural resources, and institutions performing high-temperature research were described.

Of the Scandinavian work on metals, very well known is the Swedish development of Kanthal and Super-Kanthal heating elements.

Sweden also is well known for its art and table glass, but there is much basic ceramic research in progress there, as well as in the other Scandinavian countries. Most of the Swedish work at present is in the field of solid state reactions. Norway is conducting much work on gas-solid equilibrium and is studying the properties of mixed sulfite salts. Work is progressing in Denmark on the structural studies of solid solutions.

Glass research is being conducted in both Norway and Sweden. Notable is the Norwegian work by Grjotheim showing that the boron anomaly is caused by a change from four-fold coordination in pure B_2O_3, to three-fold coordination in sodium borate melts, which is just the opposite of the original interpretation of Warren. Sweden is doing much work on the structure of glass, particularly on the effect of oxygen ion distribution. This work is supported by the Swedish glass industry at the Institute of Glass Research, and results are published in *Glasleknisk Tidsskrift.*

Glass in Petrochemicals

(*Continued from page* 141)

The extent, as well as the type, of catalyst surface influences the speed and kind of chemical reaction taking place. The amount of submicroscopic surface area of a given quantity of the catalyst, therefore is an important property and is measured by the apparatus shown in Fig. 2. This surface can be considered as the wall area of very minute pores in the catalyst. The diameters and lengths of the pores are often of the same order of magnitude as the dimensions of the reacting molecules.

How well do you know your glass?

THE GLASS ON THE LEFT IS:

- ☐ 1. Photosensitive
- ☐ 2. Nonreflective
- ☐ 3. Reflectorized
- ☐ 4. Smoked

Ordinary glass used in picture framing often throws back annoying glare, makes the picture hard to see. New nonreflective glass, shown at left, catches no distracting reflections, eliminates glare. In 70 years as a supplier of Soda Ash to the glass industry, Wyandotte has seen many advances in glass technology. Today, as in the past, Wyandotte is a working partner supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

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Measuring Catalyst Surface Area

A known weight of catalyst is placed in one of the three small glass bulbs at the base of the apparatus. High vacuum and heat are applied to drive all the adsorbed gases and moisture from the pores of the catalyst which is then cooled to about –314°F by submerging the catalyst bulb in a thermos bottle of liquid nitrogen. Precise quantities of pure nitrogen gas are transferred through the glass system at the left side of the apparatus to the catalyst where, because of the low temperature of the catalyst, the nitrogen is adsorbed on the surfaces of its pores. The change in pressure of the nitrogen in the system accompanying this adsorption is then precisely measured.

The surface area of the catalyst is calculated by using the pressure measurements, the calibrated volume of the glass system, and the temperature of, and known area occupied by, nitrogen molecules on the surface. Rather complicated mathematical calculations derived by S. Brunauer, P. H. Emmett and E. Teller are involved, but, in principle, the area of the nitrogen molecule multiplied by the number of molecules adsorbed on the surface of the catalyst in a layer only one molecule deep (obtained from pressure, volume and temperature information) gives the area of the catalyst surface. Catalysts with surface areas of 300 to 400 square yards per gram are not uncommon.

Selecting the Catalyst

In order to discover a satisfactory catalyst for a particular chemical reaction, much experimentation is needed. Even though the process may eventually be conducted at very high temperatures and pressures much of the initial screening work on catalysts can be done in glass reactors. This allows the experimenter to perform many tests quickly and to observe the catalysts in action. Often a change in color of the reacting gases or liquids will indicate how the reaction is going.

Figure 3 shows a complete assembly used in the experimentation leading to the discovery of catalysts of superior utility for making syanogen from hydrogen cyanide. The glass reactor is contained in an electric furnace (it is opened to show the reactor). The reacting gases are continually fed to the reactor, and the product is recovered as a gas or liquid in the recovery system following the reactor.

Extraction

After the details of a process are worked out at the laboratory bench, the process must be checked out on an around-the-clock basis and design data must be collected so that a plant which will perform the necessary operations with a minimum expense can be built. One of the important pilot plant operations is the continuous separation of the various products of the reaction. This can take the form of an extraction operation.

In large glass and glass and metal columns, like those shown in Fig. 4, the product stream is passed counter current to an extracting solvent which removes the de-

sired product from the product stream. The success of this process depends on the efficiency with which the two streams are contacted.

Either packing materials such as Berl saddles (used in the column on the left), perforated metal plates with risers (on the right), or other types of packing materials or plates can be used. With glass towers one may observe both the degree of mixing occurring in the column and the maximum rates at which the liquids may be pumped through the tower. These particular columns are 2″ and 3″ in internal diameter, 10 to 20 ft. long, but even larger ones are used in pilot plant work.

Conclusion

A few of the many forms of complex glassware have been described which are needed in the modern petrochemical laboratory. The skill of the scientific glass blower is very important to the success of such research and development work.

New Books

(*Continued from page* 172)

refinement of atomic standards of length and frequency, and establishment of a vibration pickup calibration service.

Progress in extension of the calibration range of optical pyrometers from 2,400° to 3,800°F is described, as well as development of a high-current arc as a source of controlled temperatures, and the design of a special type of high-temperature resistance thermometer for interpolating between fixed points on the International Temperature Scale.

Research data has been collected for the ultimate establishment of additional fixed points on the pressure scale. In this project, equipment was developed for studying the behavior of materials at pressures up to 1,500,000 lb/in.^{2}.

Glass and Mold Temperatures

(*Continued from page* 147)

dition is obtained in Miller one-piece blank molds—an expected result of their uniform cross section, which contributes to uniform flow of heat. However, the Owens temperature conditions are good when considering the factors of mold structure which upset uniformity of heat flow. Owens blank molds are subject to higher temperatures than Miller blank molds, due first to contact with hotter glass and second to narrow-neck versus wide-mouth operation. Similarly, the cyclical variations from maximum to minimum for Owens is slightly greater than for Miller blank molds.

7. References

1. Holscher, H. H.: Feeding and Forming. Handbook of Glass Manufacture (ed. by F. V. Tooley). New York: Ogden Publ. 1953, pp. 303—387.
2. Turner, W. E. S. (and other): The Viscosity and Working Characteristics of Glasses. I—*J. Soc. Glass Technol. 26* (1942) pp. 215—237; *27* (1943) pp. 94—112, 207—237; *29* (1945) pp. 199—232, 233—249. [Ref. *Glastechn. Ber. 22* (1948/49) S. 265; *24* (1951) S. 161, 162, 163; *25* (1952) S. 115.
3. Trier, W.: Temperaturmessungen in Glasformen. *Glastechn. Ber. 28* (1955) S. 336—351. [English transl.: *Glass 33* (1956) pp. 113-118, 165—170, 217—223.]

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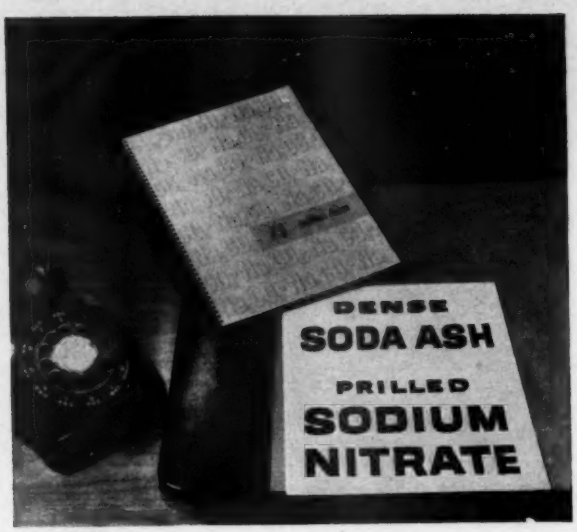

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4. Babcock, C. L. and McGraw, D. A.: Application of Glass Properties Data to Forming Operations. Glass: Ind. *38* (1957) pp. 137—142 [Ref. *Glastechn. Ber. 31* (1958) S. 67.]
5. Holscher, H. H.: Technically Speaking about the New Owens-Illinois Technical Center. Glass Ind. *36* (1955) pp. 627—634. [Ref. *Glastechn. Ber. 29* (1956) S. 103.]
6. Roeser, W. F. and Mueller, E. F.: Measurement of Surface Temperatures. *Bur. Stand. J. Res. 5* (1930) pp. 793 to 802.
7. Soaman, R. B.: The Pyrometry of Solids and Surfaces. Cleveland: *Amer. Soc. Met.* 1940. 98 pp.
8. Standard Definitions of Terms Relating to Glass and Glass Products. ASTM C162—56. *ASTM-Standards of Glass and Glass Products.* Philadelphia, Pa.: *Amer. Soc. Test. Mat. Ed.* 1957. pp. 71—84. (Also: *Glass Glossary, Bull. Amer. Ceram. Soc. 27* (1948) pp. 353—362.)

LETTERS TO THE EDITOR

This column is being introduced as a literary meeting place for readers who wish to share ideas, express opinions, and ask questions on glass, its manufacture and its applications. Your letters are most welcome.

Measuring Stresses in Glass

Dear Sir:

I was interested to see in the current issue of The Glass Industry (Research Digest, January, page 36) a description of a simplified method of measuring stresses in glass. This reminded me of a method that was published many years ago which seems to be as accurate, and is certainly simpler, in that it only calls for a minimum of apparatus.

The reference to this is *The Journal of Scientific Instruments*, by J. G. Holmes (London), 1940. 17 pages, 227-228. The equipment described by Holmes merely calls for a piece of 1" plate glass approximately 1 foot long x ½" wide, a clamp to hold it and two pieces of polaroid. By using this in the way described in the article quoted, it is possible to estimate stresses to 0.04λ.

This very simple method, which has been used quite widely in the laboratories of this company, does, I think, deserve wider recogition.

DR. W. M. HAMPTON
Chance Brothers Limited
Nr. Birmingham, England

Nickel and Cobalt Films

Dear Sir:

In the December 1959 issue, page 696, the Girard formulation refers to the use of:

Nickel sulphate	80 grams
Sodium hypophosphite	24 grams
Sodium citrate	12 grams
Boric acid	8 grams
Ammonium chloride	6 grams
Water	1 liter

Instead of sodium citrate, the text should read sodium acetate.

SAMUEL WEIN
Consultant

Flat Glass

Dear Sir:

We note that the report on the flat glass industry for 1959 (January, page 17) was erroneously credited to another Bureau within the Department of Commerce (National Bureau of Standards) instead of Business and Defense Services Administration.

MARIAN B. BORRONE
Commodity Industry Analyst
Consumer Durable Goods Division

Thank you for setting the record straight.

ED.

Dr. Navias Retired? No!

Dear Sir:

In 1954 I retired from being Manager of the Ceramic Section to that of being a Consultant (*1960 Toledo Award Winner*, January, page 12). This is not a retirement. It is a change of position. Actual retirement will not occur until September 1962 when I will have reached the age of 65.

LOUIS NAVIAS, Consultant
Ceramic Studies Section
Metallurgy & Ceramics
Research Department
General Electric Company

RESEARCH DIGEST

(*Continued from page* 174)

(4) Activation energies for devitrification growth rate and for glass viscosity change by approximately the same percentage with change in alumina content over the range $0.225 < (Al^{3+}/Si^{4+}) \times 10^2 < 1.097$.

(5) Both $\overline{A}$ and μ_0^{-1} pass through minima as a function of alumina content in similar fashion to B and E_{vis}.

(6) The anomalous behavior of Corning fused silica with respect to the glasses made from Cab-O-Sil-"O" is probably due to differences in water content and to nonalumina impurities.

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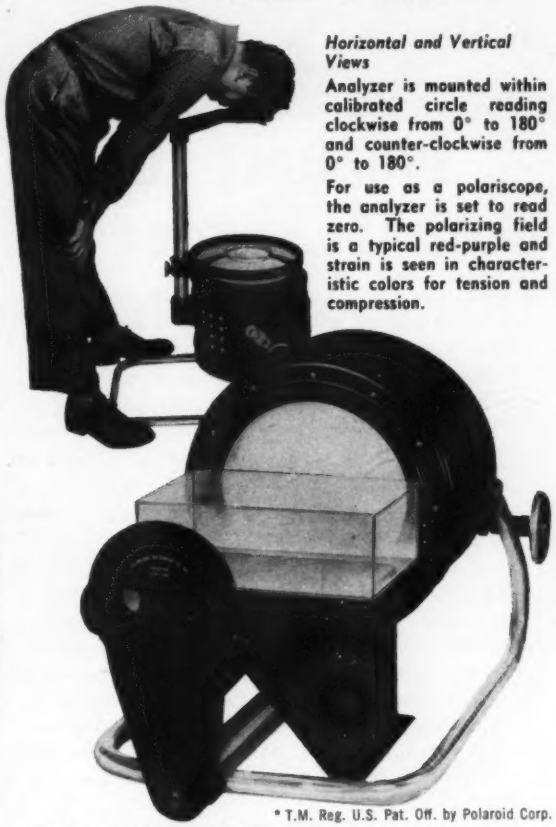

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